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DOE/MA-0064/4
Volume 4 of 7

Congressional Budget Request

General Science and Research
Uranium Enrichment
Geothermal Resources Development Fund

Volume 4

FY 1987

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller

February 1986

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DOE/MA-0064/4
Volume 4 of 7

Congressional Budget Request

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Uranium Enrichment
Geothermal Resources Development Fund

Volume 4

FY 1987

U.S. Department of Energy
Assistant Secretary,
Management and Administration
Office of the Controller
Washington, D.C. 20585

February 1986

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DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

URANIUM ENRICHMENT

GEOTHERMAL RESOURCES DEVELOPMENT FUND

VOLUME 4

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DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before The Energy and Water Development Subcommittees:			
Energy Supply Research and Development	1,967,490	1,696,298	1,254,162
Uranium Enrichment	237,956	190,512	---
General Science and Research	724,860	655,928	773,400
Atomic Energy Defense Activities	7,322,321	7,231,664	8,230,000
Departmental Administration	128,602	150,319	151,082
Alaska Power Administration	3,233	3,245	2,881
Bonneville Power Administration	284,771	330,000	276,100
Southeastern Power Administration	35,744	---	19,647
Southwestern Power Administration	31,208	29,191	25,337
Western Area Power Administration	218,230	195,910	240,309
Western Area Power Emergency Fund	---	---	---
Federal Energy Regulatory Commission	54,543	41,989	20,325
Nuclear Waste Fund	327,669	499,037	769,349
Geothermal Resources Development Fund	121	69	72
Subtotal, Appropriations Before the Energy and Water Development Subcommittees	$11,336,748	$11,024,162	$11,762,664

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATIONS

(in thousands of dollars)

	FY 1985 Actual BA	FY 1986 Estimate BA	FY 1987 Request BA
Appropriations Before Interior and Related Agencies Subcommittees:			
Alternative Fuels Production	$ 1,169,895	$ ---	$ ---
Clean Coal Technology	---	---	---
Fossil Energy Research and Development	289,048	311,954	82,767
Naval Petroleum and Oil Shale Reserves	156,874	13,002	127,108
Energy Conservation	457,436	427,512	39,433
Energy Regulation	27,139	23,423	21,850
Emergency Preparedness	6,045	5,750	6,044
Strategic Petroleum Reserve	2,049,550	107,533	---
Energy Information Activities	60,919	57,724	59,651
Subtotal, Interior and Related Agencies Subcommittees	4,216,906	946,898	336,853
Subtotal, Energy and Water Development Subcommittees	11,336,748	11,024,162	11,762,664
Subtotal, Department of Energy	15,553,654	11,971,060	12,099,517
Permanent - Indefinite Appropriations:			
Payments to States	1,052	570	570
Total, Department of Energy	$15,554,706	$11,971,630	$12,100,087

Department of Energy
F Y 1987 Congressional Staffing Request
Total Work Force

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
ENERGY & WATER SUBCOMMITTEE				
HEADQUARTERS	4,865	4,965	-18	4,947
FIELD	9,133	9,185	111	9,296
SUBCOMMITTEE TOTAL	13,998	14,150	93	14,243
INTERIOR SUBCOMMITTEE				
HEADQUARTERS	1,353	1,304	-166	1,138
FIELD	907	896	-226	670
SUBCOMMITTEE TOTAL	2,260	2,200	-392	1,808
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

DEPARTMENT OF ENERGY
F Y 1987 CONGRESSIONAL STAFFING REQUEST
TOTAL WORK FORCE

	FY1985 FTE USAGE	FY1986 CONGR REQ	FY1987 -FY86	FY1987 CONGR REQ
10:ENERGY SUPPLY RESEARCH AND DEV	937	934	-34	900
HEADQUARTERS	811	820	-28	792
FIELD	126	114	-6	108
15:URANIUM ENRICHMENT	69	66	1	67
HEADQUARTERS	58	55	1	56
FIELD	11	11	0	11
20:GENERAL SCIENCE AND RESEARCH	37	39	0	39
HEADQUARTERS	37	39	0	39
25:ATOMIC ENERGY DEFENSE ACTIVITI	2,618	2,702	131	2,833
HEADQUARTERS	496	518	9	527
FIELD	2,122	2,184	122	2,306
30:DEPARTMENTAL ADMINISTRATION	3,307	3,332	-5	3,327
HEADQUARTERS	1,721	1,726	0	1,726
FIELD	1,586	1,606	-5	1,601
34:ALASKA POWER ADMINISTRATION	37	38	0	38
FIELD	37	38	0	38
36:BONNEVILLE POWER ADMIN	3,510	3,480	0	3,480
FIELD	3,510	3,480	0	3,480
38:SOUTHEASTERN POWER ADMIN	38	40	0	40
FIELD	38	40	0	40
42:SOUTHWESTERN POWER ADMIN	186	186	0	186
FIELD	186	186	0	186
46:WESTERN AREA POWER ADMIN	1,181	1,160	0	1,160
FIELD	1,181	1,160	0	1,160
50:WAPA - COLORADO RIVER BASIN	219	219	0	219
FIELD	219	219	0	219
52:FEDERAL ENERGY REGULATORY COMM	1,617	1,659	0	1,659
HEADQUARTERS	1,617	1,659	0	1,659
54:NUCLEAR WASTE FUND	238	292	0	292
HEADQUARTERS	123	147	0	147
FIELD	115	145	0	145
56:GEOTHERMAL RESOURCES DEV FUND	2	1	0	1
HEADQUARTERS	2	1	0	1
65:FOSSIL ENERGY RESEARCH AND DEV	714	700	-161	539
HEADQUARTERS	151	135	-26	109
FIELD	563	565	-135	430
70:NAVAL PETROL & OIL SHALE RES	104	104	-9	95
HEADQUARTERS	23	23	0	23
FIELD	81	81	-9	72
75:ENERGY CONSERVATION	333	352	-134	218
HEADQUARTERS	208	227	-79	148
FIELD	125	125	-55	70
80:EMERGENCY PREPAREDNESS	74	71	0	71
HEADQUARTERS	74	71	0	71
81:ECONOMIC REGULATION	377	340	-50	290
HEADQUARTERS	377	340	-50	290
85:STRATEGIC PETROLEUM RESERVE	178	152	-32	120
HEADQUARTERS	40	27	-5	22
FIELD	138	125	-27	98
90:ENERGY INFORMATION ACTIVITIES	480	481	-6	475
HEADQUARTERS	480	481	-6	475
94:ADVANCES FOR CO-OP WORK	2	2	0	2
FIELD	2	2	0	2
GRAND TOTAL	16,258	16,350	-299	16,051
ADJUSTMENT		-132	-198	-330
ADJUSTED TOTAL	16,258	16,218	-497	15,721

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

VOLUME 4

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DEPARTMENT OF ENERGY

Proposed Appropriation Language

General Science and Research Activities

(Including Transfer of Funds)

For expenses of the Department of Energy, activities including the purchase, construction and acquisition of plant and capital equipment and other expenses incidental thereto necessary for general science and research activities in carrying out the purposes of the Department of Energy Organization Act (Public Law 95-91), including the acquisition or condemnation of any real property or facility or for plant or facility acquisition, construction, or expansion; purchase of passenger motor vehicles (not to exceed [13] 12 for replacement only); [$691,400,000] $773,400,000, to remain available until expended [of which $6,000,000 shall be derived by transfer from Operation and Maintenance, Southeastern Power Administration]. (Public Law 99-141, making appropriations for energy and water development, 1986.)

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

GENERAL SCIENCE AND RESEARCH

(Budget Authority in thousands of Dollars)

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
High Energy Physics	$541,915	$494,858	$546,700
Nuclear Physics	181,440	164,472	224,200
High Energy and Nuclear Physics Program Direction	2,205	2,092	2,500
Subtotal, General Sciences	725,560	661,422	773,400
Transfer of Appropriation	-700	-6,000	---
Less Use of Prior Year Balances and Other Adjustments	---	506	---
Total, General Science and Research.	$724,860	$655,928	$773,400

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW
HIGH ENERGY AND NUCLEAR PHYSICS
GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
High Energy Physics					
Physics Research					
Operating Expenses..	$106,300	$106,268	$106,268	$118,600	$+12,332
Subtotal.....	106,300	106,268	106,268	118,600	+12,332
Facility Operations					
Operating Expenses..	172,715	175,095	175,095	213,400	+38,305
Capital Equipment...	58,700	69,984	69,984	77,500	+ 7,516
Construction.....	114,000	55,049	55,049	41,700	-13,349
Subtotal.....	345,415	300,128	300,128	332,600	+32,472
High Energy Technology					
Operating Expenses..	90,200	88,462	88,462	95,500	+ 7,038
Subtotal.....	90,200	88,462	88,462	95,500	+ 7,038
Total					
Operating Expenses..	369,215[a/]	369,825	369,825	427,500	+57,675
Capital Equipment...	58,700	69,984	69,984	77,500	+ 7,516
Construction.....	114,000	55,049	55,049	41,700	-13,349
Total High Energy Physics.....	$541,915[a/b/c/]	$494,858[c/d/e/]	$494,858	$546,700[c/]	$+51,842
Nuclear Physics (NP)					
Medium Energy Nuclear Physics					
Operating Expenses..	$ 73,810[f/]	$ 73,131	$ 73,131	$ 85,000	$+11,869
Subtotal.....	73,810	73,131	73,131	85,000	+11,869
Heavy Ion Nuclear Physics					
Operating Expenses..	49,008	50,150	50,150	63,700	+13,550
Subtotal.....	49,008	50,150	50,150	63,700	+13,550
Low Energy Nuclear Physics					
Operating Expenses..	13,322	12,087	12,087	15,700	+ 3,613
Subtotal.....	13,322	12,087	12,087	15,700	+ 3,613
Nuclear Theory					
Operating Expenses..	9,300	8,999	8,999	10,500	+ 1,501
Subtotal.....	9,300	8,999	8,999	10,500	+ 1,501
Capital Equipment.....	12,700	13,403	13,403	16,000	+ 2,597
Construction.....	23,300	6,702	6,702	33,300	+26,598
Total					
Operating Expenses....	145,440[g/]	144,367	144,367	174,900	+30,533
Capital Equipment.....	12,700	13,403	13,403	16,000	+ 2,597
Construction.....	23,300	6,702	6,702	33,300	+26,598
Nuclear Physics.....	$181,440[h/j/]	$164,472[j/k/m/]	$164,472	$224,200[j/]	$+59,728

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
General Science Program					
Direction					
Operating Expenses..	$ 2,205[n/]	$ 2,092[n/p/]	$ 2,092	$ 2,500[n/]	$ + 408
Program Direction.....	2,205	2,092	2,092	2,500	+ 408
Total					
Operating Expenses..	$516,860	$516,284	$516,284	$604,900	$+88,616
Capital Equipment...	71,400	83,387	83,387	93,500	+10,113
Construction.....	137,300	61,751	61,751	75,000	+13,249
Subtotal General Science and Research.....	$725,560	$661,422	$661,422	$773,400	$+111,978
Transfer of Appropriation.....	0	- 6,000	0	0	0
General Science and Research.....	$725,560	$655,422	$661,422	$773,400	$+111,978
Staffing Total FTE's..	37	39	39	39	0

Authorization: Section 209, P.L. 95-91

a/ FY 1985 total does not include $3,720,000 transferred to the SBIR program.
b/ FY 1985 total reflects an ADP general reduction of $2,165,000.
c/ Totals reflect a reduction of $4,000,000 in FY 1985, $7,500,000 in FY 1986 and $8,000,000 in FY 1987 for management initiative savings.
d/ FY 1986 total reduced by 22,042,000 in accordance with P.L. 99-117, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).
e/ $200,000 has been transferred to the Assistant Secretary for Environmental Safety and Health.
f/ Includes $3,100,000 Defense Programs support of Clinton P. Anderson Meson Physics Facility (LAMPF) operations.
g/ Total does not include $1,425,000 transferred to the SBIR program.
h/ FY 1985 total reflects an ADP general reduction of $835,000.
i/ Totals reflect a reduction of $1,300,000 in FY 1985, $2,500,00 in FY 1986, and $2,700,00 for management initiative savings.
k/ Total reduced by $7,328,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).
m/ $100,000 has been transferred to the Assistant Secretary for Environmental Safety and Health.
n/ Totals reflect a reduction of $5,000 in FY 1985, $15,000 in FY 1986, and $25,000 in FY 1987 for management initiative savings.
p/ Total reduced by $102,000 in accordance with P.L. 99-117, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW

High Energy and Nuclear Physics

The Department's General Science programs are concerned with basic research to discover and understand the fundamental constituents of matter and energy and the basic forces in nature. Understanding of the laws of nature and the basic components from which matter and energy, in all their varied forms are composed, forms the foundation upon which all of modern science and technology rests. Deeper understanding correspondingly contributes, sometimes in spectacular ways, to all scientific disciplines and to our Nation's technological base. History has shown that this type of basic research has significant long-term benefits. For example, the discovery of both nuclear fission and nuclear fusion resulted earlier in the century from this kind of basic research. This Department, and its predecessor agencies, has a history of effectively building, managing and operating the large, high technology facilities which are essential for the conduct of research in high energy physics and in nuclear physics. The Department serves as the lead agency for these programs.

The Department's General Science programs are organized into two interrelated scientific programs, High Energy Physics and Nuclear Physics. While these programs are not directly associated with energy technology in the near or mid-term, they support basic research whose aim is to provide new knowledge which will have long-term scientific and technological impacts on energy development and utilization, and on other aspects of our society. The salaries, benefits and associated costs of the staff of the High Energy Physics and Nuclear Physics programs are also included in the General Science category as a separate program, called General Science Program Direction.

Matter is made up of substances known as the chemical elements. The smallest distinguishable unit of an element is the atom. Within the atom, there is a central part called the nucleus which contains most of the mass of the atom. The constituents of the nucleus, neutrons and protons, along with the mesons which play a key role in the nuclear force, are now believed to be made up of elementary particles, called quarks. The Nuclear Physics program strives to attain an understanding of the structure and properties of atomic nuclei and the forces governing their motion and interactions at the most elementary level possible. The High Energy Physics program is an exploratory field of basic research which strives to reach the ultimate description of matter and energy through discovering and studying the properties of the most basic constituent building blocks of matter (such as quarks), the nature and relationship of the four known basic forces acting among them, and the most elemental transformations between energy and matter. In recent years outstanding progress has been made toward the unification of the forces of nature and toward understanding the ultimate structure of matter in terms of basic constituent quarks and leptons. In achieving these levels of knowledge, United States high energy physicists have won or shared in three Nobel prizes during the last six years.

A major current objective of High Energy Physics is the conceptual unification of the basic forces into a single comprehensive theoretical framework. Part of the recent great progress in science has been a reduction in the apparent number of basic forces through the conceptual unification of the weak nuclear and electromagnetic forces into what is now called the electroweak force. The recent experimental evidence for the existence of the W and Z^0 particles, together with experimental discoveries during the past decade of neutral weak currents and of particles with charmed quark

and even heavier quark constituents, all support this conceptual unification. The electromagnetic and weak nuclear forces can now be viewed in a natural way as different aspects of one electroweak force. There is now increasing anticipation that the unification of the strong nuclear and electroweak forces into one "grand unified" force may be possible, thereby reducing the apparent number of basic forces in nature to only two. The ultimate goal is to incorporate the gravitational force, also, which would bring all basic forces into a single unified framework. Exactly what will follow from the various stages of unification cannot be predicted in any detail. One can certainly, however, anticipate profound impacts analogous to those which followed the unification of electricity and magnetism by Maxwell late in the 19th century, and the unification of matter and energy by Einstein early in this century. The basic experimental technique used is to study the results of violent collisions of very high energy particles in a high energy beam with the fixed target or with particles or antiparticles in a second high energy beam. In these collisions many entirely new forms of matter can be created in energy/matter interchanges. The study of these reaction products reveals properties of the underlying building blocks and basic forces involved.

The Nuclear Physics program is a comprehensive program of interdependent experimental and theoretical investigations of atomic nuclei. The program's goals include an understanding of the fundamental forces of nature within nuclei using the variety of nuclei available to attack specific problems unaddressable in simpler systems. The Nuclear Physics experimental program depends upon the operation of large and complicated accelerator facilities which provide a variety of projectile beams required for forefront nuclear research. Not only are many of the experimental and theoretical tools similar to those of High Energy Physics, but also the progress in the two fields interact synergistically. For example, developments in understanding of the laws of nature and theoretical projections have led to development of a new theoretical framework, quantum chromodynamics (QCD), which now provides the fundamental basis of our understanding of the strong nuclear force. Experiments with nuclei will allow comprehensive tests of this theoretical development and will provide guidance for future development of the theory into extended systems.

The General Science programs support a few large accelerator and colliding beam facilities which are available to all qualified scientists on the basis of the merit of their scientific proposals. More than 75% of the research in high energy physics is done by collaborative groups of university-based scientists. Proposals from university and laboratory user groups for accelerator research time are evaluated by scientific program committees which recommend those proposals with the greatest scientific promise. The High Energy Physics program operates almost exclusively in this mode, while Nuclear Physics, in addition to such national facilities, also supports dedicated accelerator facilities located on the campuses of four leading universities. To complement, interpret, and guide the experimental work, each program supports a vigorous theoretical research effort at universities and at the national laboratories.

The U.S. has been the world leader in science and technology and has derived many economic benefits from that leadership. The Department of Energy and its multiprogram laboratories play an important role in the nation's scientific enterprise that is essential for our preeminence. A central feature of this role has been the construction and operation of large, specialized scientific facilities that are used by scientists from universities and industry as well as the national laboratories. Many of the scientific facilities in our multiprogram laboratories are old or are becoming old and their scientific productivity will soon become marginal. In order to make further progress in certain fields, new, more powerful facilities are required.

In the past few years, the Department has given special attention to correcting deficiencies at its laboratories in environment, health, safety, security, safeguards, multiprogram general purpose facilities and other such areas. However, less attention has been paid to improving the essential scientific facilities required to accomplish the main scientific mission of the laboratories, i.e., preeminence in certain key fields of research. Three facilities that have been identified by the scientific community as being the most critical to the future needs of the Department's basic research programs are: 1-2 GeV Synchrotron Radiation Source - Lawrence Berkeley Laboratory; 6 GeV Synchrotron Radiation Source - Argonne National Laboratory; and Advanced Steady State Research Reactor - Oak Ridge National Laboratory. One is needed for advances in the area of General Science: a relativistic heavy ion collider for nuclear physics.

Program Highlights

A major feature of the High Energy Physics program in FY 1987 will be the first operation for research of the Tevatron proton-antiproton colliding beam capability at Fermilab and of the Stanford Linear Collider (SLC) electron-positron collider at SLAC. Both of these provide world forefront capabilities for the U.S. An important goal in FY 1987 is to bring these facilities into operation for research. The program will also include operation and research utilization of the fixed target program at Fermilab, the Alternating Gradient Synchrotron (AGS) at Brookhaven National Laboratory including its unique high energy polarized proton beam, and the Positron-Electron Project (PEP) and SPEAR colliding beam program at SLAC. The request provides support for participation by university based groups in experimental research including accelerator user group efforts and non-accelerator experiments, and for theoretical research efforts. The FY 1987 program also includes funding for a continuation of advanced technology research and development, for both accelerators and detectors.

The capital equipment request for High Energy Physics in FY 1987 gives special emphasis to meeting the highest priority needs for detectors to use the major new capabilities being provided by the Tevatron I proton-antiproton collider at Fermilab and by the SLC electron-positron collider at SLAC. The equipment request for FY 1987 is essential to make it possible for these new detectors to be completed by FY 1989 and thereby permit more effective utilization of the new U.S. High Energy Physics facilities now being completed at Fermilab and at SLAC. Implementation of the research programs at these new facilities without undue delay is critical to the strength of the U.S. High Energy Physics program for the remainder of the 1980's and early 1990's.

The construction request for FY 1987 provides for continuation of the Fermilab computing upgrade and the AGS Accumulator/Booster at BNL; completion of the SLC and Tevatron I projects and an approximately constant level of AIP and GPP.

In FY 1987, Nuclear Physics national facilities are expected to be operated at approximately the same level as FY 1985 and slightly above the level projected for FY 1986. In late FY 1986, the Tandem/AGS Heavy Ion Transfer Line construction project at Brookhaven National Laboratory (BNL) will be completed. In FY 1987, research programs will be initiated which utilize this facility to study relativistic heavy ion collisions, in a previously inaccessible energy regime. The Transfer Line couples the BNL Tandem and Alternating Gradient

Synchrotron (AGS) accelerators to provide heavy ion beams up to energies of 14 billion electron volts per atomic mass unit (GeV/AMU) for atomic nuclei up to sulfur (32 AMU). This AGS/Tandem facility will provide heavy ion beams more energetic than have been previously available anywhere in the world, and will create conditions which ultimately may lead to exotic new states of nuclear matter which have never before been observed in the laboratory.

In nuclear theory, FY 1987 will see much activity directed at questions of how quarks, gluons, and their interactions determine the makeup and behavior of nuclei. Experimentalists, as well as theorists, will continue to be involved in a variety of internationally cooperative research programs including solar neutrino studies, relativistic heavy ion experiments, and low energy antiproton interactions. In FY 1987, research at Brookhaven National Laboratory supporting the future design of a relativistic heavy ion collider will also be continued.

The highest priority for new construction in basic nuclear research in the United States is the Continuous Electron Beam Accelerator Facility (CEBAF). Construction will be initiated in FY 1987 and supporting research and development for this facility will continue. CEBAF will be a major facility centering on an electron linear accelerator complex capable of delivering intense, continuous beams in the energy range from 500 to 4,000 MeV. CEBAF's combination of continuous beam, high intensity, and high energy, incorporating the most modern technologies, will provide a unique world-class research facility. Research at the facility will address a crucial class of problems facing nuclear physics to provide the correlation and transition between the traditional and emerging descriptions of nuclear dynamics. The goal is to synthesize into a unified description the traditional picture of nuclei--based on nuclear and mesonic degrees of freedom--and developing understanding which incorporate the underlying structure of quarks and gluons.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

HIGH ENERGY PHYSICS

VOLUME 4

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DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
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HIGH ENERGY PHYSICS
GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
High Energy Physics					
Physics Research					
Operating Expenses..	$106,300	$106,268	$106,268	$118,600	$+12,332
Subtotal.....	106,300	106,268	106,268	118,600	+12,332
Facility Operations					
Operating Expenses..	172,715	175,095	175,095	213,400	+38,305
Capital Equipment...	58,700	69,984	69,984	77,500	+ 7,516
Construction.....	114,000	55,049	55,049	41,700	-13,349
Subtotal.....	345,415	300,128	300,128	332,600	+32,472
High Energy Technology					
Operating Expenses..	90,200	88,462	88,462	95,500	+ 7,038
Subtotal.....	90,200	88,462	88,462	95,500	+ 7,038
Total					
Operating Expenses..	369,215[a/]	369,825	369,825	427,500	+57,675
Capital Equipment...	58,700	69,984	69,984	77,500	+ 7,516
Construction.....	114,000	55,049	55,049	41,700	-13,349
Total High Energy Physics.....	$541,915[a/b/c/]	$494,858[c/d/e/f/]	$494,858	$546,700	$+51,842
Staffing					
FTP/Total FTEs.....	(Reference General Science Program Direction Decision Unit)				

Authorization: Section 209, P.L. 95-91

a/ FY 1985 total does not include $3,720,000 transferred to the SBIR program.
b/ FY 1985 total reflects a reduction of $2,165,000 for ADP general reduction.
c/ Totals reflect a reduction of $4,000,000 in FY 1985, $7,500,000 in FY 1986 and $8,000,000 in FY 1987 for management initiative savings.
d/ FY 1986 total includes $6,000,000 transfer of appropriation.
e/ FY 1986 total reduced by $22,042,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).
f/ $200,000 has been transferred to Assistant Secretary for Environmental Safety and Health.

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer. (1)	General Reduction (2)	Management Initiatives (3)	Pay Cost Restoration (4)	FTE General Reduction (5)	Gramm-Rudman-Hollings (6)	ES&H Transfer/ Reprogramming (7)	Subtotal (8)	Comparability Adjustments (9)	Total (10)
High Energy Physics (ER)										
Physics Research										
Operating Expenses	$111,300	$ -300				$ -4,732		$106,268		$106,268
Subtotal	111,300	-300				-4,732		106,268		106,268
Facility Operations										
Operating Expenses	187,800	-4,700				-7,805	-200	175,095		175,095
Capital Equipment	73,100	—				-3,116	—	69,984		69,984
Construction	55,500	2,000				-2,451	—	55,049		55,049
Subtotal	316,400	-2,700				-13,372	-200	300,128		300,128
High Energy Technology										
Operating Expenses	92,400	—				-3,938	—	88,462		88,462
Subtotal	92,400	—				-3,938	—	88,462		88,462
Subtotal, High Energy Physics.	520,100	-3,000				-22,042	-200	494,858		494,858
General Reduction:										
Operating Expenses	-5,000	5,000								
Capital Equipment	—	—								
Construction	2,000	-2,000								
Total, General Reductions	-3,000	3,000								
Management Initiatives:										
Operating Expenses										
Capital Equipment										
Construction										
Total, Management Initiatives										
Pay Restoration										
Use of Prior Year Balances (HEP)										
Operating Expenses										
Capital Equipment										
Construction										
Total, Prior Year Bal. (HEP)										

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
HIGH ENERGY PHYSICS
(In thousands of dollars)

1986 Appropriation enacted	$516,900
1986 Gramm-Rudman reduction	- 22,042
1986 adjusted	$494,858
o Funding required to maintain constant level of program activity	+ 29,692
o Substantial increase in facility operations funding - First operation of two new world-class HEP facilities -- Tevatron collider - world's highest energy proton-antiproton collider -- SLC - world's highest energy electron-positron collider - Reduced operation of other HEP accelerator capabilities - Average facility utilization near the 50% level	+ 27,790
o Physics research at a level consistent with the operating level of facilities	+ 5,960
o Continuation of advanced technology R&D for accelerators and detectors	+ 1,730
o Capital equipment, with special emphasis on needs at Fermilab for Tevatron I detectors and at SLAC for SLC detector	+ 3,320
o Construction at reduced level of effort - Continuation of Fermilab Central Computing Upgrade (+11,000) - Continuation of construction on AGS Accumulator/Booster (+1,470) - AIP & GPP at about constant level of effort (+1,500) - Reduced requirements for construction of Tevatron I and SLC in FY 1986 (-30,620)	- 16,650
1987 budget request	$546,700

High Energy Physics

The High Energy Physics program supports basic research which seeks to discover the fundamental constituents of matter and to understand the laws of nature that govern the behavior of matter and energy. Past discoveries and new understanding resulting from these activities have helped lay the foundation for much of the highly technological world in which we live.

The Department of Energy provides over 90% of the Federal support for this most basic scientific endeavor, and serves as Executive Agent for the national program. The Department has responsibility for planning for the national program, with the goals of achieving a forefront and productive program and maintaining a competitive world leadership position for the United States.

During this century, the forefront of scientific investigation has advanced to studies of ever more fundamental constituents of matter, from research on molecules to research on atoms, atomic nuclei, the constituents of nuclei (protons and neutrons), and recently on even more elemental objects called quarks and leptons. The framework for understanding all natural phenomena has rested on the belief that they can be described in terms of four fundamental forces and a small set of basic constituents of all matter. The "electromagnetic" force describes how atoms are formed from nuclei and electrons and how molecules are formed from atoms, and is the cornerstone to understanding the periodic table of elements, chemistry, electronic communication and biological processes. The "weak nuclear" force describes processes such as the radioactive decay of unstable nuclei and the interactions of neutrinos. The "strong nuclear" force describes how the sun and stars produce so much energy and, together with the weak nuclear force, explains the relative abundances of the chemical elements. The "gravitational" force describes falling objects, orbiting celestial bodies, the formation of black holes, and the large scale features of the universe such as the clustering of galaxies.

One facet of the recent great progress in science has been the conceptual unification of the weak nuclear and electromagnetic forces into a single force -- the electroweak force. Recent conclusive experimental evidence for the existence of the W and Z particles, the carriers of the weak force, together with the earlier discoveries of weak neutral currents and of particles with heavy quark constituents, confirm major predictions of this conceptual unification. The electromagnetic and weak nuclear forces can now be viewed in a natural way as different aspects of a single electroweak force. The 1979 Nobel Prize in Physics was awarded to three theoretical high energy physicists (including S. Glashow and S. Weinberg from the U.S.) for their work toward this unification. The experiment at CERN in which the W and Z particles were discovered, and for which C. Rubbia and S. Van der Meer received the 1984 Nobel Prize in Physics, included DOE-supported U.S. participants. Recent experimental evidence contains tantalizing hints that may signal a breakthrough to new physics beyond the electroweak unification, and could shed light on the mechanism responsible for the unification.

There is now a theory of the strong nuclear force, called quantum-chromodynamics, which is based on the same principles as the electroweak theory. As a result there is strong anticipation that the unification of the strong nuclear and electroweak forces into one "grand unified" force is possible, reducing the number of basic types of force in nature to two. The picture of nature which is presented in terms of the unified electroweak force, quantum chromodynamics, and the quark and lepton constituents is called the Standard Model.

The enormous energy scale at which grand unification is anticipated to occur can be derived from basic theoretical techniques for whose development the 1982 Nobel Prize in Physics was awarded to K. Wilson, a U.S. theoretical physicist. The ideas involved in grand unification can be used to give possible explanations for the observed excess of matter relative to antimatter in our universe. Other possibilities arising from grand unification models are that protons, which were previously thought to be absolutely stable, may eventually decay; that neutrinos, which were previously thought to be massless, may in fact have a mass; and that isolated magnetic poles of enormous mass (perhaps a billion times that of a proton) may exist. The 1980 Nobel Prize in Physics was awarded to two U.S. high energy physicists, J. Cronin and V. Fitch, for experimental research which indicated that certain elemental processes are not exactly reversible. This lack of exact reversibility, together with the mechanism involved in proton decay, may be combined to explain the observed excess of matter relative to antimatter in the universe. Special emphasis in the high energy physics experimental program is focused on testing various predictions of the grand unified theories. Any verification of these predictions by the experiments currently in progress would be a truly major scientific breakthrough.

These new concepts also have profound implications for astrophysics, where they help provide an understanding of how the universe evolved from the postulated primordial big bang to its present state, and whether the universe will expand forever or perhaps contract again in the distant future to another fireball. Interesting scenarios of the early expansion of the universe are being formulated which outline possible explanations to account for the matter, energy and disorder in the universe. Recent discoveries and planned investigations in high energy physics provide crucial experimental input to these developments.

The ultimate goal of this type of research is to incorporate the gravitational force into the framework of unification, thereby bringing all of the basic forces into a single unified framework. Exactly what new insight will follow from the various stages of unification cannot be predicted in any detail. However, one can certainly anticipate profound changes in the way we think about matter and energy and the physical universe, and this in turn will result in many changes and benefits analogous to those which followed the unification of electricity and magnetism by Maxwell late in the 19th century and the unification of matter and energy by Einstein early in this century.

Progress in high energy physics research is based on a complex and continuing interplay of advances in experiment, theory and technology. Each of these areas is strongly dependent for its progress on the advancement of the other two. High energy physics experiments expand the horizons of theoretical and technical knowledge, and the range of possible experiments is determined by technological as well as conceptual capabilities and limitations. Physicists frequently have to invent new and unique apparatus and novel techniques in order to carry out the experiments of greatest interest, thereby contributing directly to the advanced technological resources of the country.

To probe into the depths of matter -- into the domain of quarks, gluons, and other new particles -- it is most effective to use intense beams of very energetic particles, which are only available from high energy particle accelerators. By studying the results of the violent collisions of these accelerated particles with other particles, in a dense fixed target or in another beam of high energy particles, information is acquired about the constituents of the particles, about the forces which act within and between them, and about the transformations which occur between matter and energy.

The high energy particle accelerator and colliding beam facilities to be operated by the Department in FY 1987 include: the Tevatron collider at the Fermi National Accelerator Laboratory (Fermilab) providing 900 GeV on 900 GeV proton-antiproton collisions; the SLC collider at the Stanford Linear Accelerator Center (SLAC) providing 50 GeV on 50 GeV electron positron collisions; the Tevatron superconducting magnet proton synchrotron at Fermilab providing proton beams of about 800 GeV and numerous secondary beams for fixed target experiments; the 50 GeV linear electron accelerator at SLAC providing injected beams for the PEP storage ring (15 GeV on 15 GeV) and for the SPEAR storage ring (4 GeV on 4 GeV), in addition to the SLC mentioned above; and the 30 GeV proton synchrotron, the Alternating Gradient Synchrotron (AGS), at Brookhaven National Laboratory (BNL). Each of these DOE accelerator centers provides a unique set of experimental research capabilities, complementary to the others. As an ensemble they provide the foundation for a comprehensive forefront national program in high energy physics research.

A major part of the funding of the high energy physics program is required to meet the direct needs of the accelerator laboratories to develop, maintain and operate the major accelerator, colliding beam and detector facilities. The facilities at these laboratories provide the primary source of experimental data for high energy physics research in this country; about 75% of this research is carried out by university-based scientists. In this sense, most of the funding provided to the accelerator laboratories also can be considered as necessary indirect support to the university research programs.

At Fermilab, the world's first superconducting high energy accelerator has routinely operated, delivering 800 GeV protons to serve a number of fixed target experiments. The Tevatron I project, which provides the capability for operating the superconducting synchrotron as a 900 GeV on 900 GeV proton-antiproton colliding beam storage ring, is scheduled for first operation for research late in FY 1986. The Tevatron I has already had a successful pre-operating test. The Tevatron II project, scheduled for completion in FY 1986, provides a number of new and upgraded secondary beam enclosures and experimental halls for the fixed target research programs. Many of the capabilities provided by Tevatron II are already in operation.

At SLAC, the principal emphasis in recent years has been the systematic study of electron-positron collisions at center of mass energies between 3 GeV and 30 GeV. An important extension of this capability will be provided by the Stanford Linear Collider (SLC), which is to commence operation for research in FY 1987. This project has as a major goal the development and demonstration of the fundamental technical feasibility of using linear accelerators with precisely controlled, high intensity, micron-sized beam pulses to provide a reliable source of high luminosity electron-positron collisions. The successful demonstration of the SLC capabilities will be a major achievement in advanced accelerator technology and a critical early step toward a new generation of electron-positron colliders at energies well beyond those which would be considered feasible with circular colliders. Successful operation of the SLC in FY 1987 will also provide access to a previously unexplored physical domain, giving the first opportunity to study the scientifically important physics made possible by the anticipated copious production of the Z^0 boson in these high energy electron-positron collisions at energies near 100 GeV.

At BNL, the research program will make use of the recently developed unique capability for accelerating high energy polarized protons in the energy range up to 26 GeV, and also of new and upgraded secondary beam lines and detectors for a new generation of rare K-decay experiments which will test certain important theoretical predictions.

The SLC and Tevatron colliders will provide forefront research facilities for the next several years. By the mid 1990's, however, the U.S. High Energy Physics program will need new accelerator capabilities if it is to remain at the scientific frontier. Although electron-positron linear colliders show promise for the future, the technologies required for a significant step forward in energy and luminosity need much development and such a machine is not expected to be practical for at least 15 to 20 years. By contrast, the technology for a very high energy superconducting proton-proton collider is in hand and such a machine is the logical next step in the program.

Thus R&D efforts for the future of the high energy physics program are being focused on a large proton-proton collider with an energy of 20 TeV (trillion electron volts) per beam and high luminosity, up to $10^{33} cm^{-2} sec^{-1}$. Recent rapid progress in particle physics, including the discovery of the W and Z particles, has emphasized the importance of experiments in the mass range up to several TeV where new phenomena are expected, including new forms of matter with unique properties. Although the Standard Model agrees well with most experimental data, there are critical unanswered questions which can only be explored at higher energy. The 20 TeV proton beam energy would allow an exploration of this new physics domain. The new facility would have immense physics potential for truly major advances in understanding the fundamental nature of matter. It would operate in an energy domain where there are no existing or planned facilities anywhere in the world, and it would assure a world competitive U.S. high energy physics program from the mid-1990's into the next century. Such a project has been made technically possible by the outstanding successes of the substantial U.S. High Energy Physics R&D efforts in superconducting magnet technology, demonstrated most specifically by the successful operation of the Tevatron superconducting magnet synchrotron at Fermilab.

Accelerator R&D related to the next generation proton collider, called the Superconducting Super Collider (SSC), was initiated in 1984, largely as a redirection of efforts from earlier planned accelerator R&D. The 1984 work included R&D on technical options (particularly with regard to superconducting magnets), cost reduction studies, and a Reference Designs Study (RDS) which established technical feasibility and developed credible preliminary cost and schedule estimates. Research and development activities in FY 1985 included R&D to confirm RDS assumptions; cost reduction studies; further R&D on superconducting magnet designs to provide the technical basis for selection of the magnet type which would yield the best performance at the lowest facility cost; studies to refine the definition of the scope of the facility and to develop a cost performance optimized design; and development of a technical site criteria report. In FY 1986, SSC related research and development includes advanced accelerator R&D to develop a cost/performance optimized design for the selected type of superconducting magnet, to develop cost effective techniques for fabrication of full length superconducting magnets, and to develop conceptual systems designs. This program will provide the technical information for an in-depth Departmental review of plans and designs for an SSC this summer. The direction and emphasis of the accelerator R&D program, especially the work on superconducting accelerator magnets and associated systems, in FY 1987 will depend on the results of this review.

In addition to research carried out using high energy accelerators in the U.S., the Department's high energy physics program supports experiments which use the capabilities of unique foreign accelerators and also some experiments which do not require beams from particle accelerators. The research carried out at facilities overseas takes advantage of unique research opportunities offered by foreign accelerator facilities which have capabilities not available in the U.S. There is a long history of successful and mutually beneficial international cooperation in high energy physics which includes participation by scientists from one region doing

experiments on accelerators in another region. Access is on the basis of the scientific merit of proposals and without charge for use of the facilties. The research using particles from non-accelerator sources includes studies of very rare processes such as the theoretically predicted decay of the proton, and searches for neutrino mass and isolated magnetic monopoles. The proton decay experiments employ large detector systems located in deep underground laboratories to provide an environment with a very low level of background radiation.

The FY 1987 request for operating expenses is $427,500,000. The major feature of the program in FY 1987 will be the first operation for research of the proton-antiproton colliding beam capability provided by Tevatron I, and of the 50 GeV on 50 GeV electron-positron colliding beam capability provided by the SLC. The program will also include operation and research utilization of the recently upgraded fixed target facilities at Fermilab, of the BNL AGS with its fixed target program including rare kaon decay experiments and its unique high energy polarized proton beam, and of the SLAC PEP and SPEAR colliding beam facilities. There are major incremental costs associated with operation of the new world forefront Tevatron and SLC collider facilities. These two new research capabilities ensure a world leading position for the U.S. program. The request brings these new research facilities into operation and accommodates an overall facility utilization level near 50 percent. The request provides continuing support for university based groups including user group efforts at U.S. and foreign accelerators, non-accelerator experiments, and theoretical research efforts. The FY 1987 program also includes funding for a continuation of advanced technology accelerator and detector R&D.

The FY 1987 capital equipment request of $77,500,000 meets the high priority needs for the detectors required to implement strong research programs based upon the new capabilities provided by the Tevatron proton-antiproton collider at Fermilab and by the SLC electron-positron collider at SLAC. The equipment request for FY 1987 is essential to make it possible for these new detectors to be completed in FY 1989 and thereby permit most effective utilization of the new U.S. High Energy Physics facilities being completed in FY 1986 at Fermilab and SLAC.

The FY 1987 request for construction funds is $41,700,000. This program includes continued work on upgrading of the central computing capability at Fermilab ($14,157,000) which is required for the analysis of the large volume of new physics data coming from the Tevatron program, to continue construction of the AGS Accumulator/Booster at BNL ($3,500,000) and to complete construction of the SLC ($976,000) and Tevatron I ($367,000). Funds are also requested for Accelerator Improvement Projects (AIP) ($11,500,000), and for General Plant Projects (GPP) ($11,200,000).

The AIP projects are essential on an annual level of effort basis for maintaining the reliability and efficiency, as well as the scientific effectiveness, of the existing accelerator facilities. Needs for AIP funding will increase in FY 1987 with the major new facilities coming into operation at Fermilab and SLAC. GPP projects are required to keep the general plant of the laboratories, including buildings, utilities and roads, in viable operating condition. The High Energy Physics program has the responsibility to provide for the full GPP needs of the multi-program Brookhaven National Laboratory as well as those of the single-purpose laboratories, Fermilab and SLAC.

The High Energy Physics program is described in terms of three subprograms: Physics Research, Facility Operations and High Energy Technology. Although these three functions within the program are discussed as separate sub-programs, they are not

independent. Each is coupled to the other two and cannot exist separately. The close interaction and dynamic nature of these three subprograms may require that some adjustments among them be permitted during the year in order to ensure the most effective program and the best use of overall program funds.

The High Energy Physics program supports numerous university research contracts in which there is substantial cost sharing by the universities. The universities provide their contributions in a number of ways, such as partial salaries to investigators, provision of laboratory space and machine and electronic shop facilities, computing time and/or equipment, and direct funding contributions for services and equipment. The High Energy Physics program encourages such cost sharing policies to achieve maximum utilization of available Federal funds. In addition, there is cost sharing in a number of experiments by foreign participants, including substantial contributions to major detectors such as the Japanese and Italian support of the Collider Detector Facility (CDF) at Fermilab.

Physics Research	FY 1985	FY 1986	FY 1987 Request
Operating Expenses.....	$106,300	$106,268	$118,600

The Physics Research subprogram includes the support of university- and laboratory-based research groups for the planning, preparation and execution of experiments, and for the measurement, analysis, interpretation, and dissemination of experimental results. It also supports the research of university- and laboratory-based theoretical physicists engaged in both phenomenological and formal areas of theoretical study.

Experiments in high energy physics generally require the use of large particle accelerators, together with complex detection apparatus, to study the results of the collisions of high energy particles. The DOE-supported accelerators and experimental facilities are located at three central laboratories, where they are made available to qualified scientists on the basis of the scientific merit and promise of their research projects. About 75 percent of the research done with these central facilities is performed by university-based physicists. Because of the size and complexity of a typical high energy physics experiment, users from a number of institutions frequently collaborate on a given experiment. These research teams typically include a mix of physicists, engineers, technicians, and graduate students. After a research proposal to the laboratory is accepted, the research teams participate in the design and fabrication of detectors and provide manpower for the experiment during the data-taking phase at the laboratory. There is usually significant interaction and assistance from laboratory staff, and use of laboratory support facilities, for each experiment. The entire process, from conception of the experiment to publication of results, typically takes up to five years if no major new detector is involved; if major detector design and fabrication is involved, the duration can be several years longer. U.S. user group participation in experiments utilizing unique capabilities and opportunities at foreign laboratories such as DESY (West Germany), CERN (Western Europe), and KEK (Japan) is also supported. Studies of some of the important fundamental problems in high energy physics are being carried out in experiments which do not involve the use of high energy accelerators. While experiments to search for proton decay currently represent the largest of the non-accelerator experimental efforts, there are other experiments, both proposed and in operation, including searches for free quarks, magnetic monopoles, neutrino mass, and neutrino-less double beta decay.

Theoretical research provides a framework for understanding the results of experimentation and provides suggestions for new measurements important for advancement of understanding. Experiments test existing theory, and provide the basis for extensions, revisions and modification of the theoretical framework and understanding. Because of this strong interplay between, and interdependence of, experimental and theoretical research, experimental and theoretical research groups often work closely together. High energy theoretical research presently has a strong focus on the development of a unified description of the forces in nature through generalized quantum field theories. An increasingly successful trend in theoretical research is the use and development of large-scale computing facilities to explore numerical solutions of candidate theories which are not amenable to analytic methods, along with the development of more powerful numerical and analytical techniques.

The Physics Research Subprogram also includes an Outstanding Junior Investigator program which provides research support for outstanding untenured high energy physicists who might otherwise have to leave the field due to lack of availability of permanent academic positions. This small program is very important for encouraging some of the best young scientists to remain in this field of research, and thus bears importantly on the long range vitality of the field.

The FY 1987 budget request of $118,600,000 for Physics Research is necessary to maintain the capability of the university and laboratory research groups to participate effectively in today's more complex experiments, particularly those using the new capabilities at Fermilab and SLAC; to provide a level of effort reasonably matched with the planned level of facility utilization; and to maintain the important theoretical research and non-accelerator high energy physics research programs.

Distribution by Facility

	FY 1985	FY 1986	FY 1987 Request
Fermi National Accelerator Laboratory (Fermilab)	$ 9,603	$ 9,382	$ 10,300
Brookhaven National Laboratory (BNL)	7,100	6,989	7,600
Stanford Linear Accelerator Center (SLAC)	11,106	10,818	11,900
Argonne National Laboratory (ANL)	4,920	4,787	5,300
Lawrence Berkeley Laboratory (LBL)	8,400	8,454	9,200
Universities and Other Agency Laboratories	65,171	65,838	74,300
Total Physics Research	$106,300	$106,268	$118,600

Fermi National Accelerator Laboratory

In FY 1987 $10,300,000 is requested for the support of the Fermilab in-house research effort. This level will permit continued physics research activity by Fermilab scientists, most of which is done in collaboration with university-based groups from across the country. In this mode, the Fermilab staff participate in forefront research while simultaneously providing a crucial support and liaison function for the many university users of the Fermilab facilities. A major focus of their research efforts will be the unique new opportunities for fixed target research becoming available with completion of the full set of beams and targets provided by Tevatron II construction, and for colliding beam research becoming available with the new Tevatron collider facilities.

The major lines of research to be pursued by Fermilab scientists in FY 1987 will be searches for new particles, studies of nucleon structure and constituents, and exploration of the electroweak force through neutrino interactions. The 900 GeV capability of the superconducting synchrotron, in conjunction with the upgraded and new fixed target experimental facilities, as well as the new proton-antiproton colliding beam capability, will offer many highly promising new and unique opportunities for research advances. Major experiments will study: W and Z production and searches for new phenomena in colliding beam experiments; the properties of jets of particles produced with high transverse momentum; the dimuon spectrum resulting from energetic proton collisions with a fixed target; the direct production of single photons in hadronic collisions; the characteristics of interactions of neutrinos at the higher energies now available; the substructure of nucleons using the superconducting "Chicago Cyclotron" magnetic spectrometer; and the creation of charmed and heavier quark states by photons and hadrons in experiments at new higher energies. The requested funds also include support for the Fermilab theoretical physics research program, including a small effort which explores the interface region between astrophysics and high energy physics.

Brookhaven National Laboratory

In FY 1987 $7,600,000 is required for the BNL research groups. The research capabilities at the AGS are unique, since no other accelerator covers this intermediate range of beam energies or provides similar beams of high energy polarized protons. Major research thrusts during FY 1987 will be the study of the interactions of polarized beams on both unpolarized and polarized targets utilizing the high energy polarized beam capability at the AGS, a search for neutrino oscillations, and a program of innovative studies of rare K decays. Most of this work will be performed at the AGS in collaboration with university based groups. A complementary program of theoretical analyses of experimental results and more formal theoretical studies will also be pursued.

Stanford Linear Accelerator Center

In FY 1987 $11,900,000 is requested for support of SLAC physics research groups. The first experiments at the new SLC facility will begin with the upgraded Mark II detector. The SLC experimental program will initially concentrate on studies of the Z^0 and its decay modes. PEP is expected to operate at a new record high luminosity in FY 1987 and provide excellent opportunities for new discoveries with the upgraded TPC detector. Higher precision experiments including precision measurements of electroweak asymmetries and particle lifetimes will be emphasized. Analysis of data from the SPEAR detector (Mark III) will continue concentrating on states in the Psi region to obtain a more detailed understanding of charmed quark matter. The theoretical program at SLAC includes phenomenological studies, as well as studies of fundamental issues concerning properties of the basic forces, the constituents of matter and the unification of forces.

Argonne National Laboratory

In FY 1987 $5,300,000 is requested for the ANL physics research program. ANL scientists will be participating in the analysis phase of experiments done with the HRS detector at PEP. They are also playing a major role in the study of proton-antiproton collisions with the CDF detector at Fermilab and preparation for use of the polarized proton beam at Fermilab. They also are major participants in the Soudan II nucleon decay experiment. The ANL physicists collaborate closely in these

activities with university research groups and, together with the unique ANL laboratory capabilities, provide an important technical service base for these groups. The high energy theoretical physics group at ANL focuses on the study and formulation of phenomenological models for strong interactions.

Lawrence Berkeley laboratory

The request provides $9,200,000 in FY 1987 for the LBL research programs to maintain an approximately constant overall level of activity. These funds are required for participation of the LBL research groups in experiments at SLAC, Fermilab and other laboratories. LBL scientists will play a major role in the first experiments at SLC, using the upgraded Mark II magnetic detector. LBL plays a lead role in the experimental program at PEP using the Time Projection Chamber (TPC). Groups of physicists from LBL are also playing important roles in both major detector facilities at the Tevatron collider. An important part of the LBL program is the Particle Data Center, which is the only such capability in the U.S. and which provides a valuable service function for the U.S. and worldwide high energy physics communities. Modest support for high energy astrophysics experiments in 3 degree Kelvin background radiation, supernova detection and observation, and studies of compact stellar objects are expected to continue. These experiments provide important data on elementary processes and complement other high energy physics experiments. Theoretical physics at LBL will continue to emphasize the investigation of elementary particle interactions, the fundamental structure of matter, and topics in advanced accelerator physics.

Universities and other Agency Laboratories

The Physics Research request for FY 1987 provides $74,300,000 for the support of the university-based experimental and theoretical research groups and for high energy physics research programs at the Ames Laboratory, Los Alamos National Laboratory (LANL), Oak Ridge National Laboratory (ORNL), and Pacific Northwest Laboratories (PNL). This amount is required to permit these research groups to participate effectively as users at U.S. accelerator laboratories and unique foreign facilities to perform complex forefront fixed target and colliding beam experiments; to perform new forefront non-accelerator experiments; to conceive and test innovative ideas for the next generation of experiments; and to carry out theoretical and phenomenological analyses.

The Department supports approximately 115 experimental and 65 theoretical high energy physics research groups at 90 universities across the nation, as well as the research efforts at Ames, LANL, ORNL and PNL. DOE university-based high energy experimental groups are engaged in many forefront experiments in various stages of progress, collecting data from the U.S. accelerators at BNL, Cornell, Fermilab, and SLAC, and also from European accelerators at the European Laboratory for Particle Physics (CERN) and the Deutsches Elektronen-Synchrotron (DESY), from the Japanese TRISTAN facility at KEK, and from non-accelerator settings (e.g., deep mines for proton decay). Such well-conceived and carefully executed experiments provide the basis for progress in the field. The theoretical program includes a variety of activities ranging from abstract theoretical considerations to phenomenological studies. This work includes development of powerful methods for calculating lattice gauge formulations of quantum chromodynamics, and for predicting the results of electroweak interactions and model unification theories.

	FY 1985	FY 1986	FY 1987 Request
Facility Operations			
Operating Expenses	$172,715	$175,095	$213,400
Capital Equipment	58,700	69,984	77,500
Construction	114,000	55,049	41,700
Total Facility Operations	$345,415	$300,128	$332,600

Facility Operations supports the many activities required to operate, maintain, equip, and construct the high energy accelerators, colliding beam facilities, experimental areas, secondary beams, large multi-user detector facilities, and central computing facilities which are essential to the pursuit of experimental high energy physics research.

	FY 1985	FY 1986	FY 1987 Request
Operating Expenses	$172,715	$175,095	$213,400

The operating expenses portion of Facility Operations provides funding for the accelerator and experimental facility operating crews and support personnel, the electric power, and the expendable materials and supplies required for these activities which are concentrated at the three DOE high energy accelerator centers located at BNL, Fermilab and SLAC. These accelerator facilities provide the beam time for the research work of most of the high energy physics experimental research groups in the U.S., including many who receive their direct research support from the National Science Foundation (NSF). The accelerator and colliding beam facilities required for research in high energy physics are large, complex, and expensive. Hence, they are few in number and are operated at central locations as national facilities which are made available to those physicists whose research proposals are judged to have the highest scientific promise and merit.

The complementary capabilities at the three accelerator centers provide the essential variety in types of particle beams, particle energies and beam intensities for a productive U.S. high energy physics program. At Fermilab, the superconducting magnet Tevatron provides intense beams of protons with energies up to 800 GeV and various types of secondary particle beams with the high energies and high intensities needed for forefront fixed target experiments. In FY 1987, the 900 GeV on 900 GeV proton-antiproton colliding beam facility provided by Tevatron I will be in operation for research for the first time. At BNL, the AGS provides protons with energies up to 30 GeV in the primary beam, high energy polarized proton beams, secondary particle beams, and neutrino beams, for use in fixed target experiments. At SLAC, the two-mile linear accelerator provides both electrons and positrons at energies up to 50 GeV, for High Energy Physics research at the new Stanford Linear Collider (SLC) (50 GeV on 50 GeV), the PEP storage ring facility (15 GeV on 15 GeV) and the SPEAR storage ring facility (4 GeV on 4 GeV).

In FY 1987 there are major incremental costs required to initiate operation for research of the new Tevatron proton-antiproton colliding beam facility at Fermilab and of the unique new SLC electron-positron collider capability at SLAC. The funding request in FY 1987 will provide for these new needs while permitting an average overall utilization level for HEP facilities near the 50 percent level. Good utilization of these new research capabilities is essential to a world competitive position for the U.S. program. In order to support the first research utilization of

these two new world forefront capabilities at Fermilab and SLAC, operation of the AGS at BNL, of the PEP and SPEAR facilities at SLAC, and of the fixed target facilities at Fermilab, will be reduced.

Operating Expenses
Distribution by Facility

	FY 1985	FY 1986	FY 1987 Request
Fermilab	$ 83,268	$ 84,536	$100,700
BNL	35,865	35,710	38,400
SLAC	50,835	49,783	68,600
LBL	700	718	800
Other	2,047	4,348	4,900
Total Facility Operations	$172,715	$175,095	$213,400

Fermi National Accelerator Laboratory

The FY 1987 request for Facility Operations at Fermilab is $100,700,000. There are major incremental costs at Fermilab associated with first operation for research of the world forefront Tevatron collider facility. Initiation of the colliding beam experiments requires operation of the new antiproton source; this is a major facility in its own right, including a complex target facility and two new storage ring accelerators. The superconducting magnet accelerator will be operated about six months for research in FY 1987. Operation of the entire expanded sequence of accelerators at Fermilab (Cockroft-Walton preaccelerator, linac, booster, main ring, superconducting Tevatron ring and antiproton source storage rings) will require $60,700,000. The FY 1987 program is expected to include three months of operation in the fixed target research mode at energies of about 800 GeV energy, and three months for colliding beam research. In addition about one month will be required for change-over and start up activities. Operation of the laboratory's extensive set of secondary beams, fixed target detectors, colliding beam detectors and central computing facilities will require $40,000,000. During operations for the fixed target program, about ten secondary beam lines will provide a variety of intense high energy particle beams for research use, and about 14 different experiments are expected to take data. The Fermilab fixed target research program in FY 1987 will exploit the availability of secondary particle beams of higher energies and, in most cases, higher intensities than are available anywhere else in the world. It is a world unique and truly forefront program which has high priority within the national high energy physics program. The colliding beams research program will provide the first data for the new Collider Detector at Fermilab (CDF), and simultaneously for three other small colliding beams experiments. This will provide the first exploration of subnuclear phenomena near 2000 GeV collision energies.

Brookhaven National Laboratory

In FY 1987 $38,400,000 is requested for operation of the AGS and associated experimental facilities. This will result in a somewhat reduced level of operation relative to FY 1985 and FY 1986. Of this amount, $19,500,000 is needed for accelerator operations and $18,900,000 is needed for experimental facility operations. This will support about a six month level of machine operations. The FY 1987 operating program is expected to to be divided among slow extracted beam

operation, polarized proton beam operation, and fast extracted beam operation for neutrino experiments. During the slow beam operations, approximately eight experiments will be taking data simultaneously, emphasizing the high priority rare kaon decay experiments. Also included are lease costs for the CAD/CAM computer system. In addition, the AGS will also be operated for heavy ion research which is funded by the Nuclear Physics program.

Stanford Linear Accelerator Center

$68,600,000 is requested in FY 1987 for Facility Operations at SLAC. Of the request, $40,700,000 is for the operation of the linear accelerator, SLC, PEP, and SPEAR, and $27,900,000 is for the operation of the experimental areas, detector facilities and the central computer facility (including lease costs for the IBM 3081-K and upgrades). There are major incremental costs at SLAC in FY 1987 to bring the world forefront SLC collider into first operation. The linac presently operates mostly at 60 pulses per second for injection into the PEP and SPEAR colliders; however, research operation of the SLC requires operation of the linac at 120 pulses/second. This increased pulse rate results in a large increase in power usage and in the rate of klystron and thyratron replacements. These effects, combined with the rapidly rising electric power rates from WAPA (nearly 50 percent from FY 1985 to FY 1987) and the need to purchase some power from PG&E during 120 pulses/second operation, result in the large incremental cost for SLC operation. The current plan is to operate the linear accelerator for High Energy Physics for about six months. During the 2-1/2 months for SLC commissioning the linac would operate mostly at 60 pulses/second, while during the 3-1/2 months of physics research with SLC it would operate mostly at 120 pulses/second. Research utilization of the SLC will require operation of the upgraded Mark II detector and the associated collider experimental hall. Operation of PEP is expected to continue at higher luminosity with an improved TPC detector. To permit funding for the commissioning and first operation of SLC, operations of the SPEAR and PEP storage rings will be significantly reduced in FY 1987. SPEAR will remain available for use by the Stanford Synchrotron Radiation Laboratory which is supported by the Basic Energy Sciences Program.

Lawrence Berkeley Laboratory

The request provides $800,000 for support of LBL's participation in the operation of the Time Projection Chamber (TPC) detector facility at PEP. LBL provides engineers, computer scientists, technicians, and physicists who are responsible for reliable operation of the TPC.

Other

In FY 1987, $4,900,000 is requested for special process spares and common use stores inventories and other specialized activities to meet requirements for effective operation of the accelerator laboratories. An adequate complement of spares and specialized replacement parts is essential to avoid unnecessary disruptions to the operating schedule in the event of component failures. These very complex and advanced technology facilities require many components that are not off-the-shelf items but must be custom made in advance if they are to be readily available when a replacement part is needed. In FY 1987 there are increased needs to provide adequate spares support for the new facilities at Fermilab and SLAC.

	FY 1985	FY 1986	FY 1987 Request
Capital Equipment.....	$ 58,700	$ 69,984	$ 77,500

Capital Equipment funding is required to provide the secondary beam line components, particle detection apparatus, portable shielding, and data analysis systems essential to do high quality, forefront high energy physics experiments. It is also required for replacement of accelerator and detector facility components that have worn out or become obsolete. A proper complement of detectors and secondary beams is essential for effective utilization and operation of the major high energy physics accelerator and colliding beam facilities. The world forefront detectors required for more effective utilization of the new and unique research capabilities of both the Tevatron and the SLC colliders have total costs in the vicinity of $50 million and require about five years to fabricate.

Timely introduction of new beam and detector capabilities, and the regular upgrading and modification of existing capabilities, is essential. The large scale of the equipment required for high energy physics research systems is illustrated by a few examples: a typical secondary beam line can range from several hundred feet to a mile or more in length, and requires many beam transport, beam shaping and control elements; the portable shielding required around detectors and targets can involve arrays of hundreds of shielding blocks weighing as much as 10 tons each; the analysis magnets incorporated in detection systems weigh many tons; large calorimeters of 100 tons or more are not uncommon; and electronics systems with hundreds of thousands of data channels are typically required for major detectors. A time span of as much as five years is often involved from design, through fabrication, to installation, checkout, and operation of these large systems. Examples of specific items of equipment needed include: beam transport magnets and large analysis magnets for detector systems; precision regulated power supplies; particle beam diagnostic and control systems; electronic and optical detectors with precision spatial and time resolution; high precision calorimeters and tracking chambers for colliding beam detectors; high speed and large volume data processing systems; special cryogenic components for liquid hydrogen targets and superconducting devices; and a host of specialized electronics and other items of laboratory support equipment.

In FY 1987, $77,500,000 is requested to meet the most urgent capital equipment needs of the program, with particular emphasis on the major world forefront detectors required for adequate utilization of the new colliding beam research capabilities coming into operation at Fermilab and SLAC. The needs for the D-Zero detector for the second experimental area at the Tevatron collider, and for the first fully scoped detector for the SLC (the SLD), are given special emphasis to make it possible for these new detectors to be completed in FY 1989. At Fermilab it will be necessary to upgrade the first colliding beam detector (CDF) and to upgrade the secondary beams and detectors required for experiments using the fixed target capabilities. At SLAC it will be necessary to upgrade the TPC detector for second generation experiments. At BNL, there are major capital equipment needs related to the large rare kaon decay detectors. There are also needs for university users, for non-accelerator experiments, and for U.S. participation in international collaborative experiments at unique foreign facilities.

High Energy Physics
Summary of Capital Equipment by Laboratory

	FY 1985	FY 1986	FY 1987 Request
Fermilab	$ 27,540	$ 31,115	$ 30,500
BNL	4,497	4,978	5,200
SLAC	9,070	14,552	21,000
LBL	1,730	1,436	1,600
ANL	1,280	747	700
Other DOE laboratories and universities	10,683	13,422	14,300
General Purpose Equipment (BNL)	3,900	3,734	4,200
Total Capital Equipment	$ 58,700	$ 69,984	$ 77,500

Fermi National Accelerator Laboratory

In FY 1987, $30,500,000 is requested for capital equipment for the Fermilab program. Needs for FY 1987 progress on the D-Zero colliding beam detector which is planned for completion in FY 1989 account for $12,500,000 of the request. Another major need ($8,500,000) is for the secondary beam lines and detectors which are essential for good utilization of the Fermilab fixed target research capabilities. The request also includes $3,500,000 for upgrades to the CDF colliding beam detector.

Summary of Capital Equipment Request for Fermilab

	FY 1987 Request
Detectors for Effective Utilization of Tevatron I	$ 16,000
D-Zero detector	12,500
CDF detector upgrade	3,500
Detectors and Secondary Beams for Fixed Target Program	$ 8,500
Detectors for fixed target experiments	4,700
Secondary beam line components and shielding	3,800
Base Program Needs	$ 6,000
Accelerator related equipment items	1,800
Support equipment for experimental program	1,600
General computing equipment	1,700
Technical support and site operations equipment	900
Total	$ 30,500

Several new and upgraded detectors need to be completed and brought into operation during FY 1987 for the fixed target program. The requested $4,700,000 for fixed target detectors includes $1,200,000 for approved experiments in the Neutrino Area, $2,100,000 for experiments in the Proton Area, and $1,400,000 for experiments in the Meson Area.

Several secondary beam line facilities need to be upgraded with new technical components in FY 1987. The major requirements for secondary beam transport lines include magnets, control systems and instrumentation, cryogenics for the superconducting magnets and shielding. A total of $3,800,000 is requested for such secondary beam equipment, of which the major efforts on new beams will include completion of the hyperon beam ($700,000), the polarized proton beam ($600,000) and

the new higher energy pion beams in the Meson Area ($1,300,000) and the Proton Area ($500,000). The remainder of the requested funds will be used for upgrades to about five existing beams.

Two major colliding beam detectors (one for each major interaction hall) are being fabricated at Fermilab to conduct research at the unprecedented reaction energies scheduled to become available for the first time late in 1986, when the Tevatron collider becomes operational. The Collider Detector at Fermilab (CDF) being assembled at the B-Zero interaction region of the Tevatron will be ready for research operation near the end of FY 1986. It will provide the first studies of new physics at reaction energies in the 2000 GeV range. The $3,500,000 requested for CDF in FY 1987 will provide upgrades whose need is indicated by early pre-operating experience. Fabrication of the second colliding beam detector, to be installed at the D-Zero interaction region of the Tevatron, was initiated in FY 1985. The $12,500,000 requested in FY 1987 for the D-Zero colliding beam detector will permit major progress on this detector and will maintain a schedule that makes it possible for the D-Zero detector to be completed in FY 1989.

The numerous and technologically advanced accelerator and cryogenic systems at Fermilab require replacement items of capital equipment in order to maintain good operating condition and for the replacement of worn out and obsolete units. Items needed include components of the power, vacuum, RF, controls and cryogenic systems. Equipment needed for the R&D programs is included in this category. A network of small emulators and microprocessors, to provide more efficient access by users to the Fermilab central computing complex, is also required in FY 1987. The request also provides for the standardized electronics modules and other items of support equipment provided from a centralized pool for experimental users, as well as for technical support and site operations equipment such as machine tool replacements.

Brookhaven National Laboratory

The FY 1987 request of $5,200,000 for BNL includes $4,700,000 for needs of the ongoing AGS physics program. This includes $3,000,000 for detection equipment for the BNL physics research groups, a major part of which is for the rare kaon decay experiments; $1,100,000 for components for secondary beam line modifications; $300,000 for controls and instrumentation in various parts of the AGS complex; and $300,000 for the instrumentation pool which provides modules of standardized electronic apparatus which are available to all AGS users on the basis of need. The remaining $500,000 is for equipment needed to support the advanced accelerator R&D programs.

Stanford Linear Accelerator Center

The request of $21,000,000 in FY 1987 is required to meet equipment needs related to the SLAC linear accelerator, the SPEAR and PEP storage rings, the associated experimental detection facilities, work on a fully scoped detector (SLD) for use at SLC, and the SLAC advanced accelerator R&D programs.

The request includes $14,500,000 for progress on the first full-scope SLC detector, the SLD, designed specifically for experiments at 50 GeV on 50 GeV. This detector will include high resolution calorimetry and excellent particle identification over a large solid angle, as well as the ability to identify short-lived particles by the measurement of their path length prior to decay. The FY 1987 request is needed to maintain a schedule that makes it possible for this state-of-the-art detector to be completed in FY 1989.

The $6,500,000 requested for other activities includes completion of the modification of the PEP lattice for increased luminosity and upgrading of the TPC detector. Also included are minor upgrades of the Mark II detector at SLC. Other needs to be met from this request include equipment needs in support of SLAC's advanced accelerator research and development effort, including work on advanced concepts with potential application to future linear colliders; improvements to the central computing system and its associated network, and general laboratory support equipment.

Lawrence Berkeley Laboratory

A total of $1,600,000 is requested for capital equipment needs at LBL in FY 1987. The physics research program requires $900,000 for the support of experiments at SLAC, Fermilab, and for a double beta-decay experiment. The advanced accelerator R&D effort requires $500,000 for equipment related to LBL's efforts on antiproton cooling, on very high field superconducting accelerator magnets, and on special purpose computing devices used in performing orbit tracking calculations for advanced accelerator design. There is also a need for $200,000 for equipment in support of the advanced detector development program.

Argonne National Laboratory

A total of $700,000 is requested for ANL capital equipment needs in FY 1987. This equipment will support ANL's participation in a variety of experiments, including the new polarized proton beam experiments at Fermilab and the Soudan II proton decay experiment.

Other DOE Laboratories and Universities

A total of $14,300,000 is requested to meet the capital equipment needs of other DOE laboratories and universities. The $13,000,000 requested for university programs in FY 1987 is required for experimental detection and data analysis equipment. These funds support the major apparatus needs of the experimental research programs of the university users for experiments at U.S. and foreign accelerator laboratories, and for non-accelerator experiments such as searches for nucleon decay, neutrino oscillations, double beta decay, magnetic monopoles, and studies of very high energy processes produced by cosmic radiation.

Included in the $13,000,000 are major equipment needs ($6,500,000) for user groups participating in electron-positron colliding beam experiments presently in the preparation stage at the LEP facility at CERN, in electron-proton colliding beam experiments at the German HERA facility, and at the TRISTAN colliding beam experimental program at KEK in Japan. There are needs ($2,500,000) for non-accelerator experiments such as the proton decay searches which are operated in deep mines. There are direct funding needs of the university programs ($1,200,000) for apparatus for experiments utilizing fixed target and colliding beam capabilities at Fermilab; for experiments at the SLC and PEP Colliders at SLAC; for utilization of the high intensity capability of the AGS at BNL for neutrino oscillation, rare kaon decay and polarized beam experiments. On-line computer equipment, interfacing components and peripherals, which are an integral part of experimental detector systems, and small computer systems used in scanning, measuring, and data analysis, are also required by the university experimental groups. In addition, theoretical groups based at universities have a requirement for special computing capability for some types of theoretical research such as lattice gauge calculations. These needs require $800,000. Also included is $2,000,000 for a mainframe for data reduction for the LEP 3 experiment.

The FY 1987 request also includes $750,000 for equipment needed in support of the advanced accelerator R&D efforts and $550,000 for Ames Laboratory for detector components to be used in experiments at the LEP facility at CERN.

General Purpose Equipment (BNL)

The High Energy Physics program provides funding for all general purpose equipment requirements at BNL. In FY 1987, $4,200,000 is requested for this multipurpose equipment, which is essential to the proper day-to-day operations at the Laboratory. Included are all the needs of the Laboratory's service and support divisions, central scientific computing facility and central shops, as well as equipment required to respond to health, safety, security, and environmental needs. It is important that obsolete and worn-out equipment be replaced in order to promote efficient, safe laboratory operations, to increase productivity, and to avoid high maintenance costs.

	FY 1985	FY 1986	FY 1987 Request
Construction	$114,000	$ 55,049	$ 41,700

A total of $41,700,000 in construction funding for high energy physics projects is requested in FY 1987. The projects are:

Project Title	Project No.	FY 1987 Request	Total Estimated Cost
Tevatron I (Fermilab)	81-E-218	$ 367	$ 84,000
SLC (SLAC)	84-ER-133	976	115,400
Central Computing Upgrade (Fermilab)	86-R-104	14,157	24,100
AGS Accumulator/Booster (BNL)	86-R-105	3,500	26,400
Accelerator Improvement Projects (AIP)	87-R-101	11,500	11,500
General Plant Projects (GPP)	87-R-102	11,200	11,200
		$ 41,700	

The construction request includes funding to continue the upgrade of the central computing capability at Fermilab and the AGS Accumulator/Booster at BNL, for completion of Tevatron I and SLC, and for accelerator improvements and modifications and general plant projects which are needed on an annual basis to maintain the efficiency, reliability and scientific effectiveness of the laboratories.

Tevatron I

The Tevatron I project at Fermilab will provide the facilities needed for a 1000 GeV on 1000 GeV proton-antiproton colliding beam capability. This will be accomplished by producing intense counter-rotating beams of protons and antiprotons in the Energy Saver superconducting magnet ring and bringing them into collision to produce about 2000 GeV of reaction energy, the highest available in the world. Specifically, the project includes: 1) additional refrigeration and radio frequency accelerating structures so that the Energy Saver ring can operate at 1000 GeV for proton-antiproton colliding beams; 2) an antiproton source; and 3) two experimental areas suitable for detectors to study the results of very high energy proton-antiproton collisions. The $367,000 requested in FY 1987 is the final project funding. Additional details are provided in the Construction project data sheet.

Stanford Linear Collider (SLC)

The SLC project at SLAC, will provide: 1) systems for producing intense electron and positron bunches; 2) small storage ring and beam pulse compressor to increase the density of the electron and positron bunches; 3) two semicircular arcs of small aperture magnets, housed in appropriate enclosures to bring the electron and positron beams into head-on collisions; 4) special focusing systems near the beam interaction point, including the necessary housing and associated experimental hall and staging area; and 5) the instrumentation and control systems to operate these systems.

The SLC project will accelerate beams of electrons and positrons simultaneously in the linear accelerator, separate them and transport them through two semicircular arcs at the end of the linac and then bring them into head-on collision. Successful development of the SLC will provide an essential demonstration of the technical feasibility of the new linear collider concept, which is a critical step toward future cost effective extensions of electron-positron reaction energies beyond the maximum energy practical with circular colliders. In addition, when completed in 1986, the SLC will be the first electron positron colliding beam system in the world capable of achieving an energy of 100 GeV in the center-of-mass system and is expected to produce copious quantities of the recently discovered Intermediate Vector Boson (Z^0), one of the carriers of the electroweak force. The detailed study of the Z^0 is one of the major, exciting areas of physics research indicated by present theories. The project benefits in a major way from the use of the existing 2-mile linac and supporting facilities at SLAC. The $976,000 requested in FY 1987 is the final project funding. Additional details are provided in the construction project data sheet.

Fermilab Central Computing Upgrade

Significantly upgraded central computing capabilities and capacity are required at Fermilab in order to accommodate the data acquisition rates required for forefront experiments with the new research facilities becoming operational with completion of the Tevatron construction program. The primary source of this requirement is the antiproton-proton colliding beams capability of the Tevatron, and the two major associated new detector facilities. This new research program will generate unprecedented volumes of data requiring extensive analysis and computation in order to extract the important physics results. Experiments using the higher energies and produce much higher data rates than previously experienced. Effective utilization of these new research facilities requires significantly improved computing capability at Fermilab. A recent study emphasized the urgency of the central computing upgrade to meet these needs.

The total estimated cost of this project is $24,100,000. The project was initiated with $2,968,000 in FY 1986. The concrete exterior structure of the building is to be completed with those funds. The $14,157,000 requested in FY 1987 will permit major progress on this facility, including completion of the building and the acquisition of much of the additional central processing units, peripheral data storage devices, and interfaces to user terminals. The FY 1987 request is essential to permit completion of the computing upgrade on a time scale appropriate for effective research output from the Tevatron. Final funding is planned for FY 1988. Additional details on this project are provided in the construction project data sheet entitled "Central Computing Upgrade" (Project No. 86-R-104).

AGS Accumulator/Booster (BNL)

The accumulator/booster is a 1 GeV intermediate injector to the AGS which will provide a cost effective enhancement of the capabilities of the AGS for high energy physics experiments and also for heavy ion research. It will increase the space charge limit of the AGS, permitting the intensity of proton beams to be increased by a factor of 4 (to 5 x 10^{13} protons/pulse); increase the intensity for polarized protons by a factor of 20 (to about 4 x 10^{11} protons/pulse) by permitting the accumulation of many linac pulses in the booster before injection into the AGS; and will provide the ability to fully strip and accelerate heavy ions up to mass 200 for injection into the AGS.

The increased proton beam intensity will be extremely valuable for important rare kaon decay studies and for medium energy neutrino studies for which the AGS is a world leading facility. It will also permit simultaneous operation of slow extraction and fast extraction systems, thereby permitting neutrino experiments to operate simultaneously with other experiments and considerably enhancing the cost effectiveness of AGS operations. The increase in intensity for the unique polarized proton capability of the AGS is especially important for experiments at large momentum transfer where event rates fall off rapidly. The accumulator/booster will also extend the heavy ion capability of the AGS to ions of mass 200 (gold) compared to the present limit of mass 32 (sulfur).

The TEC of the project is $26,400,000. The project was initiated with $1,915,000 appropriated in FY 1986; $3,500,000 is requested in FY 1987 to continue the project. The remaining funding is scheduled for FY 1988 and FY 1989. Additional details on this project are provided in the Construction project data sheet entitled "AGS Accumulator/Booster" (Project No. 86-R-105).

Accelerator Improvement Projects

A total of $11,500,000, which maintains an approximately constant overall level of effort, is required for Accelerator Improvement Projects (AIP) to be distributed as follows: Fermilab ($5,900,000); BNL ($2,500,000); and SLAC ($3,100,000). AIP funds are required on an annual basis to provide essential modifications and upgrades of the existing accelerator and colliding beam facilities for the purpose of ensuring their scientific effectiveness and improving their operating economy and efficiency.

It is necessary to provide new or modified research capabilities on short notice in order to accommodate the special needs of new high priority experiments. These changes are often required on a time scale much shorter than the normal two to three year Federal budget cycle. As a consequence, AIP funds are essential to permit a rapid and flexible response essential to meet the most urgent of such needs and maintain a highly effective program.

There are special needs for AIP funds at Fermilab because of the very large scale and scope of the laboratory which includes a series of seven accelerators, storage rings and pre-accelerators, as well as the extended cryogenics facilities, beam extraction systems, secondary beam lines and experimental facilities, all of which make up the complex Tevatron facility. Also in FY 1987 there will be additional accelerator facilities requiring such funds at the SLAC complex following completion of the SLC. Additional details on the AIP needs at each of the three accelerator laboratories are provided in the construction project data sheet entitled "Accelerator Improvements and Modifications" (Project No. 87-R-101).

General Plant Projects

General Plant Projects (GPP) funds are for upgrading, modification, and improvement of the general laboratory plant at BNL, Fermilab and SLAC. GPP funds are required for projects such as utilities, support buildings, roads, shops, on-site fire fighting capability, etc., and, although small compared to the capitalized value of the plant, are essential to keeping it in efficient operating condition. The FY 1987 request totals $11,200,000 for an approximately constant level of GPP at the following laboratories: Fermilab ($3,300,000), BNL ($6,000,000), and SLAC ($1,900,000). It is noted that at BNL the High Energy Physics Program has the responsibility to provide funding for all of the GPP needs of this multi-program laboratory. Additional details are provided in the construction project data sheet entitled, "General Plant Projects, Various Locations" (Project No. 87-R-102).

	FY 1985	FY 1986	FY 1987 Request
High Energy Technology			
Operating Expenses	$ 90,200	$ 88,462	$ 95,500

Progress in forefront scientific research is strongly linked to advances in technology. The performance capability of the facilities and instrumentation available to researchers affects the ability to make significant advances. Development of new accelerator and detector capabilities and of new better types of instrumentation depends not only on the development and application of new advanced technologies but also frequently requires extension of the underlying scientific and engineering principles. Research in high energy physics requires some of the most complex and technologically advanced research facilities ever built. The development of applicable supporting technology not only in response to the needs of research but also in anticipation of them is an essential feature for the DOE supported program in high energy physics.

The High Energy Technology subprogram has the specific goal of providing the technological base for improving the scientific effectiveness, reliability and efficiency of existing facilities and for extending the scientific capability of the experimental research program through new concepts and new, advanced facilities. As a byproduct, work carried out under the High Energy Technology R&D subprogram frequently pushes forward or opens up new technological frontiers, thereby contributing significantly to the national technology base and to many specific needs in other areas of science, technology and medicine. In order to sustain an effective technology R&D effort that is both responsive to the needs of and stimulates the basic physics research programs, it is necessary also to pursue a vigorous theoretical research effort into the physics and engineering principles underlying the concepts and operation of these facilities; to conduct forefront R&D in selected, promising areas of applicable technology; to develop and prove emerging ideas and concepts; and to transform these ideas and concepts into practical devices and techniques for use in physics research and elsewhere.

The High Energy Technology subprogram is subdivided into two major areas: Accelerator R&D and Experimental Facility R&D. The first is concerned with the production of particle beams and the second with the utilization of those beams for physics research. Specifically, accelerator R&D is concerned with the science and technology fundamental to charged particle accelerators, colliding beam systems, beam

extraction, and primary beam transport systems. Its goal is to develop new and improved concepts, techniques, and devices of direct application to the acceleration, storage, and transport of particle beams to be used for probing the innermost depths of matter and energy. The end products are particle beams of higher energy, increased intensity, longer stored lifetime, greater brightness (more particles per unit transverse beam area), lower cost and greater diversity. Experimental facility R&D is concerned with the targets, secondary beam transport systems, detection apparatus, and data processing systems directly involved in the physics experiments. It focuses on developing new and improved means for generating, splitting, and transporting secondary particle beams; on inventing and developing new types of instrumentation required for detecting and studying the characteristics of particle interactions produced in experiments; and on devising advanced processing techniques for the collection and analysis of data gathered in experiments.

While the purpose and thrust of the technology R&D subprogram is to ensure and extend the technology base vital to the progress of high energy physics research, the results of the advanced R&D effort frequently find significant application in other scientific and engineering disciplines. Thus, advances in the understanding of charged particle beam technology have contributed to the development of high power radiofrequency tubes, electron microscopes, semiconductor manufacture, and x-ray sources. Standardized instrumentation systems sponsored and developed by the high energy physics program, such as the recently completed FASTBUS, have become national and international standards used in other research disciplines, industrial process control and artificial intelligence. Pattern recognition methods developed for bubble chamber scanning in high energy physics were essential in the development of Computer Assisted Tomography (CAT) scanners. Superconducting magnet technology and pattern recognition methods have been applied to the new Nuclear Magnetic Resonance (NMR) devices which are expected to revolutionize medical diagnostics.

The High Energy Technology R&D activities are concentrated primarily at five DOE supported national laboratories, although an important part is carried out by universities, other laboratory and non-profit institutions, and industrial firms. The FY 1987 request of $95,500,000 for the High Energy Technology Subprogram includes a program of R&D studies in support of upgrades to maintain the scientific effectiveness of existing accelerator, colliding beam, detector and experimental facilities; in support of ongoing construction projects; and to develop very advanced concepts and techniques with potential application to future acceleration and detection facilities. The FY 1987 request includes continued R&D studies on superconducting magnets for accelerators and their optimization for future accelerators including materials development, cryogenics and manufacturability studies. Also included are magnet systems studies such as vacuum, instrumentation and control systems, and the effects on these systems and on the magnets themselves, of operating a series of magnets as a system. Important accelerator physics studies include non-linear beam dynamics, both analytical and by tracking, and the production and maintenance of bright, low emittance beams.

The studies on superconducting magnets and systems and their optimization are a high priority need for the future viability of the program. The U.S. breakthrough in superconducting magnet technology, represented most dramatically by the successful operation of the Tevatron, signifies that no future high energy proton or hadron accelerator can competitively be built anywhere without the use of superconducting magnet technology. Further, electron accelerators with capabilities significantly beyond those of the SLAC SLC and the CERN LEP machine will require new accelerator techniques and methods which are expected to require many years of R&D before coming to fruition. Thus, any new frontier high energy accelerator for the near future is expected to require the use of superconducting magnets and R&D and optimization of these magnets for future facilities has high priority. The results of the advanced

accelerator R&D program for the next generation particle collider through FY 1986 will provide the technical information for an in-depth Departmental review of an SSC type facility. Those results can be expected to have a strong impact on the direction and emphasis of the FY 1987 R&D studies particularly in the area of superconducting magnets and systems.

	FY 1985	FY 1986	FY 1987 Request
High Energy Technology			
Fermi National Accelerator Laboratory.....	$ 27,735	$ 23,360	$ 24,900
Brookhaven National Laboratory.....	19,305	18,956	20,200
Stanford Linear Accelerator Center.....	16,585	15,509	16,400
Argonne National Laboratory.....	1,681	1,436	1,700
Lawrence Berkeley Laboratory.....	8,190	7,850	8,600
Other DOE laboratories and universities.....	16,704	21,351	23,700
	$ 90,200	$ 88,462	$ 95,500*

*Allocations tentative pending departmental review of SSC.

Fermi National Accelerator Laboratory

A total of $24,900,000 is requested for Fermilab in FY 1987 for technology R&D. Of the FY 1987 request, $16,200,000 is for accelerator R&D, and $8,700,000 is for experimental facilities R&D.

Operation of the superconducting magnet ring as a proton-antiproton collider in a totally new energy regime is scheduled to begin late in FY 1986. An extensive R&D program to understand and optimize the properties and performance of the antiproton source and of the Tevatron as a storage ring will be required. Properties of the Tevatron operating with simultaneously circulating beams of protons and antiprotons will be studied with the object of improving reliability, efficiency and luminosity. The operational characteristics of the antiproton source will also be studied with the aim of improving overall performance and luminosity of the collider. Prototypes of an improved lens for the antiproton target, of higher frequency stochastic cooling systems, and of higher capability instrumentation and control systems will be fabricated and tested. R&D will be carried out to investigate ways to increase the brightness of the antiproton source, and on the feasibility of a pre-booster to improve the beam intensity of the Tevatron. R&D on advanced technologies for accelerator and colliding beam systems will also be carried out. R&D on improved superconducting magnets, cryostats and systems will continue.

As Fermilab begins to exploit the research capabilities made available by completing Tevatron I and II, there will be a special focus in the experimental facilities R&D program on the development of higher performance beam transport, targeting and beam splitting apparatus and on improved particle detectors for experiments to more effectively utilize the higher energy fixed target research capabilities. R&D will be needed in support of colliding beam experiments and detectors; particularly the new D-Zero detector. Improved triggering techniques, computer software and special on-line graphics capabilities will be developed. An important component of these efforts will be R&D aimed at improvements in computer techniques and systems. More advanced software for data collection, data reduction and graphical display of results will be required. The program will also include studies to develop advanced detector concepts.

Brookhaven National Laboratory

The FY 1987 request includes $20,200,000 for technology R&D at BNL. Of this, $17,400,000 is for accelerator R&D, and $2,800,000 for experimental facilities R&D.

The accelerator R&D related to the AGS has the goal of maintaining and improving the operating effectiveness and the scientific capability of the AGS. There will be a special effort directed toward achieving a major increase in AGS accelerated beam intensity, and improvements to the polarized beam capability. Advanced R&D on new accelerator concepts and technologies will also be pursued, with particular emphasis on studies of superconducting technology capitalizing on BNL's expertise in this area.

The experimental facilities R&D will focus on new detector and beam line developments aimed primarily at improving the unique capabilities at the AGS for polarized beam experiments, low energy neutrino studies, and rare kaon decay processes. The program also includes an effort on development of advanced detector concepts.

Stanford Linear Accelerator Center

A total of $16,400,000 is requested in FY 1987 for technology R&D at SLAC. The FY 1987 request includes $8,600,000 for support of accelerator R&D and $7,800,000 for experimental facility R&D.

In FY 1987 the SLC project will be brought into operation for research; supporting R&D will concentrate on optimizing performance and reliability and improving luminosity. Special areas of study will include development of methods for enhancing positron beam intensity; problems of stability of high current micron-sized beam pulses in the linear accelerator during acceleration; beam transport to focus the beams of electrons and positrons to a tiny spot and bring them into head-on collision; methods to control and analyze the collisions of the very high intensity micron-sized electron and positron pulses; and development of techniques for acceleration of polarized electrons.

The balance of the accelerator R&D funds will be directed toward improvements in performance, reliability, and operating efficiency of the linear accelerator and the SPEAR and PEP colliding beam devices, and toward advanced concepts. Advanced concept R&D activities at SLAC will include development of high gradient accelerating structures, development of very high power pulsed radio frequency sources, theoretical and experimental studies of new and advanced concepts of linear accelerator systems, development of advanced beam instrumentation and control devices, and development of special beam transport systems for micron sized beams.

Experimental facility R&D at SLAC in FY 1987 will be directed primarily toward the development of advanced detectors for future experiments at the SLC and PEP. Particular emphasis will be placed on R&D in support of the SLD detector.

Lawrence Berkeley Laboratory

A total of $8,600,000 is requested in FY 1987 for technology R&D at LBL. Of this amount, $5,800,000 is to be used to support advanced accelerator R&D, including studies of very high field superconducting magnets, collaborative studies with Fermilab and others on stochastic cooling techniques, and work on novel accelerator concepts such as the two-beam electron accelerator concept.

The experimental facilities R&D request of $2,800,000 is to support development of a hadron calorimeter for a major proton-antiproton experiment at Fermilab; studies of advanced detectors for use with linear colliders in collaboration with SLAC; work to improve the performance of experimental apparatus at SLAC and Fermilab; and a major initiative for the development of advanced detector concepts utilizing the special expertise of LBL in this area.

Argonne National Laboratory

A total of $1,700,000 is required for ANL in FY 1987. Of that amount, $750,000 is for accelerator R&D and $950,000 is for experimental facilities R&D.

The high energy accelerator R&D at ANL for FY 1987 is expected to be directed primarily towards work on advanced accelerator concepts, particularly on the so-called wakefield devices.

Experimental facilities R&D is expected to concentrate on research and development for new types of particle detectors; further developments of the CDF; and the development of new types of polarized targets.

Other DOE Laboratories and Universities

In FY 1987, $23,700,000 is requested to support other advanced technology programs. The request provides the increase required for the SBIR assessment and an increase of about $400,000 each for advanced detector and advanced accelerator R&D. The work under this part of the technology R&D subprogram is carried out by universities, laboratories and industry. This program presently supports contracts with about 30 institutions. The work covers a very broad spectrum of topics related to accelerators, colliding beams and detectors. The work includes studies to improve upon and optimize previously available techniques and those which seek to develop entirely new techniques. As part of optimization of available techniques, effort includes work on superconducting magnets, including materials development, cryogenics, and manufacturing techniques; other magnets systems, such as vacuum, instrumentation and control systems; and accelerator physics topics such as nonlinear beam dynamics including beam-beam effects, studies both analytically and by tracking, and the production and maintenance of bright, low emittance beams.

There are also significant needs for advanced detector R&D to develop detectors that can extend the range of investigations at present facilities and operate effectively at future accelerators and colliders. R&D is needed to develop radiation hardened detector systems and electronics which can survive in the high radiation environment near the collider interaction point at high luminosity; triggering systems and data reduction systems to handle the high event rates; and techniques for pattern recognition and time tagging and tracking of complex, high multiplicity, overlapping events.

There is also a strong need to develop new accelerator techniques, which derives from the necessity of optimizing the cost of constructing and operating the large, modern accelerator and colliding beam facilities. While there are no known physics or technology reasons why present acceleration techniques cannot be extended to much higher energies than facilities now operating or planned, the size and associated cost of much higher energy facilities based on known technology could become prohibitive.

As a consequence, resources are being directed toward discovering and developing new concepts of charged particle acceleration that are more cost effective and give higher final particle energies in devices that are smaller and more energy efficient than existing ones. Representative lines of research include collective methods of particle acceleration, wake field accelerators, laser acceleration of electrons, theories of non-linear dynamics, collective effect and space charge induced phenomena, very high frequency and high power radio frequency sources, and very high field superconducting magnets. A number of these programs are reaching the point where significant experiments and prototype fabrication are required to verify predictions and guide future R&D studies. A substantial effort in this area is critical to make it possible to provide the required future high energy physics accelerator and experimental facility capabilities in a cost effective manner.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No.: 81-E-218

3. Date A-E work initiated: 1st Qtr. FY 1981

3a. Date physical construction starts: 4th Qtr. FY 1982

4. Date Construction ends: 4th Qtr. FY 1987

5. Previous cost estimate: $82,500
Less amount for PE&D: 0
Net cost estimate: $82,500
Date: October 1984

6. Current cost estimate: $84,000
Less amount for PE&D: 0
Net cost estimate: $84,000
Date: October 1985

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1981	$ 2,000	$ 2,000	$ 2,000	$ 1,211
1982	18,000	14,100	14,100	4,182
1983	18,000	18,000	18,000	11,845
1984	20,000	20,000	20,000	29,517
1985	21,300	21,300	21,300	19,794
1986	4,700	8,233	8,233	13,000
1987	0	367	367	4,451

8. Brief Physical Description of Project

This project provides for:

1. the modification of the superconducting Tevatron accelerator ring so that it can be used as a 1 TeV proton on 1 TeV antiproton colliding-beam storage ring;
2. two experimental areas to provide facilities for simultaneous high energy physics experiments; and
3. the construction of an antiproton production, cooling and accumulation system.

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois 2. Project No.: 81-E-218

8. Brief Physical Description of Project (continued)

Additional satellite refrigerators are required to operate the superconducting Tevatron ring near the full energy of 1 TeV because superconductors, as they approach full magnetic field, will make the transition from the superconducting to normal state with decreasing amounts of energy deposited in them. Thus, extra cooling will prevent quenches of the superconducting ring at full energy. Additional rf cavities and other special devices are required to simultaneously accelerate and store protons in one direction and antiprotons in the opposite direction, and to optimize the collision configuration.

Two experimental areas to house high energy physics colliding beam detectors will be an integral part of the Fermilab Main Ring tunnel. The design of the experimental areas will allow the rapid efficient introduction of large detectors into the beams. To accomplish this, there will be separate detector assembly areas. The project also provides an overpass for the conventional magnet ring, to deflect it over the detector at one of the experimental areas.

The Fermilab scheme for production and collection of antiprotons uses the present accelerators, up to and including the main ring conventional magnet synchrotron, plus two additional new storage rings. The first of these is the debuncher ring, operating at about 8 GeV energy, which will have a large acceptance for antiprotons and will be used to debunch the beam as it comes from the antiproton production target. The second ring is the accumulator which will be used for cooling of the antiproton beam after it emerges from the debuncher, and for accumulating the antiprotons. The term "cooling of a particle beam" means reducing the energy spread of the beam. This cooling is particularly important for producing an accelerator quality beam from the dilute beam of secondary particles emerging from the antiproton production target. The accumulator will collect the antiprotons from about ten thousand targeting cycles. It then increases their density by stochastic cooling until the antiproton beam is intense enough to transfer into the Tevatron ring, where it will be accelerated and brought into collision with a counter-rotating proton beam. The project includes construction of the debuncher ring, the enclosures for the two rings, associated beam transport enclosures and the target station.

The research detectors required for experiments will be funded as capital equipment items. The major detector for the B-Zero Area is being fabricated over the period from FY 1981 through FY 1986. Substantial participation and financial assistance is being contributed by the Japanese, and also by Italian collaborators. The total DOE funding contribution for this detector is currently planned to be about $35,000,000. Work on a major detector for the D-Zero Area began in FY 1985. Effective analysis of the large volumes of data to be generated by the TeV I will require an upgrading of Fermilab computing capacity and capability.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois

2. Project No.: 81-E-218

9. Purpose, Justification of Need for, and Scope of Project

When protons and antiprotons are stored in the superconducting Tevatron ring and brought into collision, the reaction energy available for particle production will be about 2000 GeV. This is almost 50 times greater than the reaction energy which is available at Fermilab when 1000 GeV protons strike a fixed target, although the interaction rates of the colliding beams are much lower than those of the fixed target program. This reaction energy will be sufficiently high to produce the W and Z intermediate vector bosons, which are the carriers of the weak nuclear force, and to study their properties. The data from experiments done at Fermilab and at other high energy accelerators have shown that the proton behaves as though it were made up of constituents. Past experience has clearly demonstrated that extending particle physics investigations into new, much higher reaction energies has proven to be of immense scientific value. A compelling scientific expectation is the likelihood of discovering totally unexpected phenomena at this new world record reaction energy.

10. Details of Cost Estimate

		Item Cost	Total Cost
a. Engineering, design and inspection at 17% of construction costs..			$10,100
b. Construction costs.....			60,100
1. Conventional construction.....		$24,300	
a. Experimental areas.....	$11,600		
b. Ring and beam line housing.....	12,700		
2. Special facilities.....		35,800	
a. Antiproton source.....	23,500		
b. Accelerator components.....	12,300		
c. Contingency at 20% of above costs.....			13,800
Total.....			$84,000

11. Method of Performance

Design of facilities will be by the operating contractor and subcontractors as appropriate. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded on the basis of competitive bids.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois 2. Project No.: 81-E-218

12. Funding Schedule of Project Funding and Other Related Funding Requirements

	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	Total
a. Total project costs:								
1. Total facility costs:								
(a) Construction line item...	$1,211	$ 4,182	$11,845	$29,517	$19,794	$13,000	$ 4,451	$ 84,000
Total facility costs.....	$1,211	$ 4,182	$11,845	$29,517	$19,794	$13,000	$ 4,451	$ 84,000
2. Other project costs:								
(a) Direct R&D operating costs necessary to complete construction...	2,221	3,337	13,268	21,262	7,000	1,075	0	48,163
(b) Capital equipment in support of R&D.....	621	368	702	357	293	0	0	2,341
Total other project costs	$2,842	$ 3,705	$13,970	$21,619	$ 7,293	$ 1,075	$ 0	$ 50,504
Total project costs (Items 1 & 2).....	$4,053	$ 7,887	$25,815	$51,136	$27,087	$14,075	$ 4,451	$134,504

b. Total related incremental annual funding requirements (estimated life of project: 20 years)

1. Facility operating costs.....	$- 3,000*
2. Programmatic operating expenses directly related to the facility.....	2,500
3. Capital equipment not related to construction but related to the programmatic effort in the facility.....	3,000
4. GPP, AIP programmatic costs.....	500
Total other related annual funding requirements.....	$ 3,000

*Reference item 13.b. for explanation.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Tevatron I, Fermi National Accelerator Laboratory, Batavia, Illinois 2. Project No.: 81-E-218

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project funding:

1. Total facility costs

(a) Construction line item - explained in items 8, 9 and 10.

2. Other Project Funding:

(a) Direct R&D operating costs - Studies of stochastic cooling techniques will continue. R&D on the antiproton production target system and the accumulator ring are now in progress. R&D on other elements of the project, to optimize performance and minimize the costs of various subsystems, will continue through the late stages of construction.

(b) Other project-related costs - The items included in these costs are magnets, power supplies, electronics and other general equipment to support a.2(a) above.

b. Total related annual funding requirements - It is assumed that after Tevatron I comes into operation approximately one-half of Fermilab accelerator operations time will be for colliding beams. This means that the fixed target experimental areas will not be operating one-half of each year. During the colliding beam operating period, there will be a net reduction of power consumption at Fermilab of about 15 Megawatts compared to running full time for fixed target experiments, which corresponds to a savings of about $3,000,000 over six months at current power rates. The programmatic effort in the facility will require approximately 30 additional people, and additional material and supplies are required to effectively operate the facility. The acquisition of research detectors for Tevatron I will be made with capital equipment funds. In the future, it is anticipated that major detector upgrades will be required about every three years. GPP and AIP funds will be required as experience in operating the new antiproton source and utilizing the Tevatron as a storage ring indicates specific areas where improvements would be more beneficial.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

3. Date PE&D initiated: 2nd Qtr. FY 1980

3a. Date physical construction starts: 1st Qtr. FY 1984

4. Date Construction ends: 2nd Qtr. FY 1987

5. Previous cost estimate: $114,272,000
Less amount for PE&D: 2,272,000
Net cost estimate: $112,000,000
Date: October 1983

6. Current cost estimate: $117,672,000
Less amount for PE&D: 2,272,000
Net cost estimate: $115,400,000
Date: November 1984

7. Financial Schedule:

Fiscal Year	Authorizations	Appropriations	Obligations	Costs
1984	$ 32,000	$ 32,000	$ 32,000	$ 23,094
1985	60,500	60,500	60,500	49,552
1986	21,924	21,924	21,924	39,000
1987	976	976	976	3,754
Total	$115,400	$115,400	$115,400	$115,400

8. Brief Physical Description of Project

The SLAC Linear Collider (SLC) is a new type of electron-positron colliding beam facility which is an important step toward reducing the cost of very high energy electron-positron colliding beam devices to permit extension of the upper limit in energy above that which is at present fiscally feasible. The SLC will be constructed on non-government owned property at the Stanford Linear Accelerator Center (SLAC) which is located on Stanford University property. Its operation is based on the acceleration, in the linac, of an intense positron bunch and an intense electron bunch to energies of approximately 50 GeV each. At the end of the linac, the two bunches are injected in opposite directions into two arcs of magnets, arriving at a collision point where an effective interaction energy of approximately 100 GeV is achieved. After the collision point, the particles are disposed of and not used again. Because the beam is used only once, the magnets in the ring can have small aperture and, hence, low cost. Compared to storage rings, the single pass collider system operates at a relatively low repetition rate but makes up for the low collision frequency by the extremely high current densities which can be achieved at the collision point.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

8. Brief Physical Description of Project (continued)

The main components of the SLC are the energy upgrade of the SLAC linac; a transport system from the end of the linac to the small aperture magnet arcs; the magnet arcs themselves which includes the special focusing systems required near the interaction point; the necessary beam housing; an experimental hall and staging area; a high power positron production target at the 2/3rd point of the linac; a positron booster; a transport system from the positron target back to the injection end of the linac; a high peak current electron gun; two small storage rings, called damping rings, to reduce the emittances of the electron and positron beams by radiation damping; pulse compressors to reduce the length of the bunches in the storage rings before injection back into the linac; and the necessary instrumentation and control systems.

Since the SLC involves a new type of colliding beam system, its operation and the function of the various components are described below. A bunch of positrons containing approximately 5×10^{10} particles is injected into the SLAC linac. A single intense electron bunch, also of 5×10^{10} particles, is injected into the linac approximately 20 meters behind the positron bunch. A second electron bunch is injected behind the first intense electron pulse. This second electron bunch is used for the production of a new positron bunch. The first two bunches are accelerated in the linac to an energy of about 50 GeV. At the end of the linac a splitter takes the leading intense positron and the first electron bunch and starts them around the two magnet arcs in opposite directions. The function of the arcs is to transport the electron and positron bunches to a collision area where they collide head-on. In the collision area a collection of special lenses focuses the beams to a cross section of about 2 micron diameter at the collision point. After the beams pass through each other at the collision point they are disposed of and not used again.

The second electron bunch, which travels down the linac behind the electron and positron bunches, is deflected out of the linac at the two-thirds point and is directed onto a positron production target. Positrons from this production target are boosted to an energy of around 0.2 GeV by a short section of linac and transported by a separate magnetic-optical system back to the injector end of the main linac. There they and two new electron bunches from the electron gun/injection system are boosted to an energy of approximately 1.2 GeV and put into damping rings. In the damping rings the size of the beams decreases through synchrotron radiation damping to the appropriate value for re-injection into the main linac. The damping time for positrons is longer than the approximately 5 milliseconds between pulses of the collider system and, therefore, this ring must store two bunches simultaneously. The positron bunch which has been stored for the longest time is the one which is ejected from the damping ring and injected into the linac for the next pulse. During the time the .2 GeV positron beam is traveling back to the injector end of the linac, the high current electron gun produces two short pulses of electrons.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

8. Brief Physical Description of Project (continued)

These are timed to arrive at the injector just after the .2 GeV positron bunch. All three bunches of particles are accelerated in tandem through the first 100 M of the linac to 1.2 GeV energy. The positron bunch is switched to the positron damping ring and the two electron bunches into the electron damping ring. At the start of the next cycle one of the positron bunches and the two electron bunches are extracted from the damping rings, compressed longitudinally to a length of about 1 mm and injected into the linac. This total process is then repeated over and over again at the repetition rate of the linac.

9. Purpose, Justification of Need for, and Scope of Project

The SLC has two goals. First, it will develop and serve as a first test of a new colliding beam technique. This is a critical step toward achieving electron-positron collisions at much higher center-of-mass energies at lower cost per GeV than the technology used up to now -- that of the Colliding Beam Storage Rings (CBSR). Second, the SLC will increase the center-of-mass energy available for electron-positron experiments by a factor of about three above that now available at existing electron-positron CBSR's. The relatively low cost of the SLC, itself, is achieved by virtue of the fact that it uses the existing 2-mile linac.

The highest energy electron-positron colliding beam storage rings now in existence are the PEP Project at SLAC and PETRA at Hamburg, West Germany with center-of-mass energies of around 30-40 GeV respectively. The next step in circular colliders is the LEP machine, now being built by CERN physicists and engineers, which will achieve a maximum center-of-mass energy of about 120 GeV, initially with conventional radio frequency (RF) and subsequently as high as 240 GeV with superconducting RF. The version with conventional RF is estimated to cost about 1 billion Swiss Francs in 1981 value, not including labor costs.

In order to make use of the existing single linac at SLAC, the SLC has two arcs of magnets to guide the electron and positron bunches in different directions from the linac to the collision point. At the planned 50 GeV beam energy level the synchrotron radiation emitted in these magnets has a negligible effect on the total power required to operate the facility, while allowing it to be based on a single linac rather than two linacs. This project will not only provide critical input for a new accelerator technology, which promises to reduce costs for future generations of electron-positron machines, but will also contribute to a better understanding of the physical world through the important new experiments which it will make possible.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

9. Purpose, Justification of Need for, and Scope of Project (continued)

From recent research, a new theoretical concept has emerged which interprets both the weak and electromagnetic forces as different manifestations of one basic force. This concept is a form of gauge theory; the simplest form is the "standard model" of Weinberg and Salam. All of the variants of the gauge theory have one or more heavy particles which interact with the electron-positron system in the same basic way as does the ordinary zero mass photon. It is the interaction of this heavy gauge particle (Z^0) and its charged companions (W^+ and W^-) that is responsible for the properties of what is called the weak interaction. The gauge theories have had such success in explaining apparently unrelated facts that they are generally believed to be correct.

The SLC is designed to have a total energy large enough to copiously produce the neutral gauge particles, resulting in many hundreds of events per hour. The decay of these Z^0's into quarks, leptons, and perhaps other more exotic particles, will give a vast amount of information about a broad spectrum of basic physics questions ranging from the number of elementary building blocks which make up our world, and to the conditions in the early universe when it was only a few seconds old. The first evidence for the gauge particles has been found at the CERN antiproton-proton collider, but production rates are so low that experiments on this machine can give only a small fraction of the important, detailed information that can be obtained from the SLC.

Funds for detection apparatus to be used for high energy physics experiments with the SLC are included in the capital equipment budget. Equipment funds are being used to upgrade an existing detector (Mark II) previously used for lower energy experiments at PEP and for a new detector designed specifically for SLC physics. The Mark II upgrade ($11M) will be completed in FY 1986 so as to be available for physics research when SLC comes into operation early in FY 1987. Work on the new detector, called SLD, was initiated in FY 1985. SLD is expected to be completed by FY 1990, with a total DOE cost of about $40M.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

10. Details of Cost Estimate

	Item	Total Cost
A. ED&I (Excludes previously funded Plant Engineering & Design ED&I) @ 20% of construction costs, item B.		$ 16,500
B. Construction Cost:		84,000
1. Site Work, Utilities, and Structures including a) Experimental Hall; b) Collider Housing, and c) Linac-Collider Connection Tunnels.....	$ 25,500	
2. Accelerator components: a) Electron and Positron Sources; b) Energy Upgrade; c) Collider Arcs; and d) Focusing, Damping and Control Systems	58,500	
C. Standard Equipment (Cranes)		400
D. Contingency @ approximately 14% of above costs		14,500
E. Total		$115,400

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

11. Method of Performance

Design of conventional facilities will be accomplished by subcontracts. Design of technical components will be by the operating contractor (SLAC). To the extent feasible, construction procurement and installation will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

12. Funding Schedule of Project Funding and Other Related Funding Requirements

	Prior Years	FY 1984	FY 1985	FY 1986	FY 1987	Total
A. Total Project Costs:						
1. Total Facility Costs:						
(a) Construction Line Item	$ 0	$23,094	$49,552	$39,000	$ 3,754	$115,400
(b) PE&D	2,272	0	0	0	0	2,272
(c) Expense Funded Equipment	0	0	0	0	0	0
(d) Inventories	0	0	0	0	0	0
Total Direct Costs	2,272	23,094	49,552	39,000	3,754	117,672
2. Other Project Costs:						
(a) R&D Necessary to Complete Construction	0	9,867	6,713	3,736	0	20,316
(b) Other Project Related Costs:						
(1) R&D Related Capital Equipment.	0	412	300	350	0	1,062
Total Other Project Funding	0	10,279	7,013	4,086	0	21,378
Total Project Costs (Items 1 & 2)	$ 2,272	$33,373	$56,565	$43,086	$ 3,754	$139,050

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

12. Funding Schedule of Project Funding and Other Related Funding Requirements

B. Other Related Incremental Annual Costs in FY 1986 dollars (Estimated life of project: 10 years)

1. Facility operating costs (including incremental power costs)	$13,600
2. Programmatic operating expenses directly related to the facility	2,500
3. Capital equipment not related to construction but related to the programmatic effort in the facility	500
4. GPP or other construction related to programmatic effort in the facility	400
Total related incremental annual costs in FY 1986 dollars	$17,000

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

A. Total Facility

(a) Construction Line Item (no narrative required)

(b) PE&D - The SLC is a totally new kind of colliding beam system, and although the basic technology involved is well understood, the project has benefited immeasurably from Plant Engineering and Design (PE&D) funding to more firmly establish component costs and conventional facility costs and schedules. The project was provided with $300,000 of PE&D funding in FY 1980, $750,000 in FY 1981, $907,000 in FY 1982, and $315,000 in FY 1983. The FY 1980 PE&D money funded a preliminary geological study of the site, preliminary tunnel and experimental hall design, and the study of alternative site layouts. The FY 1981 PE&D funding was allocated to more detailed structural design (Title I) of the linac/collider and connecting tunnels. In June 1981, SLAC retained the services of Tudor Engineering as an A/E firm to perform Title I and Title II design on the SLC project. The FY 1982 and FY 1983 PE&D funding supported completion of Title I and partial Title II design for SLC conventional facilities.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Stanford Linear Collider (SLC)
Stanford Linear Accelerator Center (SLAC)
Stanford, CA

2. Project No. 84-ER-133

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements (continued)

(c) Expense Funded Equipment - none anticipated for this project.

(d) Inventories - no inventories are anticipated for this project.

2. Other Project Funding

(a) R&D Necessary to Complete - funds provided in High Energy Physics Research, Accelerator Research and Development.

(b) Other Related Funding Provide the capital equipment and plant funding needed in support of the R&D effort.

B. Total Related Funding Requirements:

The programmatically useful lifetime of the facility is estimated to be about 10 years.

1. Facility operating costs include the incremental costs of accelerator operations, experimental area operations, and related research and development efforts. These costs are for salaries, electric power, materials and supplies, with the dominant cost element being the electric power charges.

2. Programmatic Operating Expenses Directly Related to the Facility - this estimate is for high energy physics research to be performed by SLAC in-house physicists or physicists from the user community.

3. Capital Equipment Related to the Programmatic Effort in the Facility - this estimate is for general capital equipment needed to support research at the facility. It will provide for upgrading research detectors, data recording and analysis instrumentation and miscellaneous laboratory instruments. It does not provide for any major detection system.

4. GPP or Other Construction Related to Programmatic Effort - this estimate is a general "level of effort" which would provide for minor structures and utility extensions as well as modifications and improvements (AIP) of the facility to maintain its scientific effectiveness and productivity.

5. Other Costs - no narrative required.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Central Computing Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 86-R-104

3. Date A-E work initiated: 1st Qtr. FY 1986

3a. Date physical construction starts: 2nd Qtr. FY 1986

4. Date construction ends: 4th Qtr. FY 1988

5. Previous cost estimate: $23,900
Less amount for PE&D:
Net Cost estimate: $23,900
Date: November 1984

Current cost estimate: $24,100
Less amount for PE&D: 0
Net cost estimate: $24,100
Date: August 1985

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1986	$ 23,900	$ 2,968	$ 2,968	$ 2,000
1987	0	14,157	14,157	9,000
1988	0	6,975	6,975	13,100
Total	$ 23,900	$ 24,100	$ 24,100	$ 24,100

8. Brief Physical Description of Project

The proposed project is comprised of two parts:

a) The acquisition of a major computing capacity and capability upgrade, including additional central processors, additional disc and tape storage devices, and additional interfaces to support both online user terminals and access to special purpose data processors designed for the particular requirements of high energy physics data analysis.
b) A building to house the upgraded central computing system and support personnel.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Central Computing Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 86-R-104

9. Purpose, Justification of Need for, and Scope of Project

a. Central Computing System Upgrade

Fermilab's central computing facility serves a wide variety of needs, the major ones being the analysis of data from experiments, theoretical physics calculations, accelerator design calculations, and stress analysis and magnetic field calculations used in the design of magnets and other equipment. A large central computing facility has proven itself to be the most cost effective solution to these computing needs in terms of hardware and software support, utilization of peripherals, and flexibility of computer configurations. The Fermilab central computing facility represents the only major facility of this kind which is accessible to the U.S. university participants in Fermilab experiments for the analysis of their data. At present the Fermilab central computing facility consists of three Cyber 175 computers. A lease-purchase contract for additional hardware will increase the total capacity to the equivalent of seven Cyber 175's in the period FY 1984 - FY 1986. However, an evaluation of the projected computing load has indicated that another increase in the computing capacity of at least a factor of five will be needed in FY 1986 - FY 1987. This increase in load is primarily due to the large additional data analysis requirements of the new colliding beam detectors for Tevatron I. The computer system upgrade requested here will meet these new needs, and will be chosen to provide the basis for growth during the remainder of the 1980's as the accelerator intensity improves and the experiments are refined.

b. Building to house Upgraded Central Computing System

Since 1973 Fermilab's central computing system, tape storage, and on-line computer maintenance have been housed in Wilson Hall. Growth in subsequent years has now led to a degree of congestion which is severely affecting the efficiency and reliability of these operations. Since additional space in Wilson Hall to house additional computing hardware is unavailable, it is proposed to move these activities to a separate building specifically designed for this usage, where it will also be much easier to provide proper security for the very high value equipment which is involved.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Central Computing Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 86-R-104

10. Details of Cost Estimate

	Part A Computer Upgrade Total Cost	Part B Building Item Cost	Part B Building Total Cost
a. Engineering, design and inspection at 2.3% of Procurement and Installation (Part A) and 10.6% of construction costs (Part B)..	$ 300		$ 700
b. Construction costs.....		$ 300	6,800
1. Improvements to land including road, parking & landscaping...		6,400	
2. Building.....			
a. Basic Structure..... $3,800			
b. Mechanical..... 1,600			
c. Electrical..... 900			
d. Conveying System (Elevator).... 100		100	
3. Utilities.....	13,500		
4. Procurement.....	200		
5. Installation.....	$14,000		7,500
Subtotal.....			
c. Contingency at approximately 11% of the above cost for Part A and 15% for Part B.....	1,500		1,100
Total Estimated Cost by Part.....	$15,500		$ 8,600
Total Estimated Cost.....			$24,100

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Central Computing Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 86-R-104

11. Method of Performance

Design of conventional and special facilities will be by the operating contractor. To the extent feasible, construction, procurement, and installation will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

12. Funding Schedule of Project Funding and other Related Funding Requirements

	FY 1986	FY 1987	FY 1988	Total
a. Total project costs				
1. Total facility costs				
a. Construction line item.....	$ 2,000	$ 9,000	$13,100	$24,100
2. Other project costs				
a. Existing equipment relocation....	0	50	50	100
Total project costs.....	$ 2,000	$ 9,050	$13,150	$24,200

b. Other related annual funding requirements (estimated life of project: 25 years)	
1. Building maintenance and operating cost (including power).....	$ 600
2. Programmatic operating expenses directly related to the computing facility.....	12,000
3. Capital equipment not related to construction but related to the programmatic effort in the computing facility.....	1,500
4. GPP or other construction related to programmatic effort in the facility.....	0
Total related annual funding requirements.....	$14,100
Less: Costs associated with the operation of the existing computing facility in its present location.....	- 9,900
Net incremental annual costs resulting from the construction of the new building and the operation of the upgraded computing facility.	$ 4,200

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Central Computing Upgrade
Fermi National Accelerator Laboratory
Batavia, Illinois

2. Project No.: 86-R-104

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project costs:

1. Construction Line Item (No Narrative Required)

2. Other project costs
   a. Existing equipment relocation - the existing computing equipment presently located in Wilson Hall will be relocated to the new building as construction is completed, at an estimated cost of $100,000.

b. Total related annual funding requirements. It is estimated the facility will be used 25 years for its programmatic purpose.

1. Facility operating costs. The major elements comprising the annual operating costs are electricity for lighting and air conditioning, natural gas for heating and labor for custodial and maintenance.

2. Programmatic operating expenses directly related to the facility. The estimate given here is based on the cost of the programmatic effort presently being provided for the existing facility.

3. Capital equipment not related to construction but related to the programmatic effort in the facility. This represents an appropriate funding level for central computer system enhancements.

4. GPP - No narrative required.

5. General - The net incremental costs to operate the upgraded facility are shown in item 12 at $4,200,000. The present Fermilab central computing facility is currently operational in its Wilson Hall location and would incur an annual expense of about $9,900,000 in FY 1986. These costs would continue if the upgrade were not undertaken. The incremental costs cover items such as additional personnel, hardware and software maintenance charges, custodial, maintenance, and repair needs for the building, as well as utility costs. It has been assumed that the electrical power cost at the new facility will be partially offset by savings at Wilson Hall.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

3. Date A-E work initiated: 1st Qtr. FY 1986

3a. Date physical construction starts: 3rd Qtr. FY 1986

4. Date Construction ends: 4th Qtr. FY 1989

5. Previous cost estimate: none

6. Current cost estimate: $26,400
Less amount for PE&D: 0
Net cost estimate: $26,400
Date: May 1985

7. Financial Schedule

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1986	$ 2,000	$ 1,915	$ 1,915	$ 1,100
1987	24,400	3,500	3,500	3,500
1988	0	16,085	16,085	12,100
1989	0	4,900	4,900	9,700

8. Brief Physical Description of Project

The Accumulator/Booster (A/B ring) is a rapid cycling synchrotron that acts as a booster injector to the Alternating Gradient Synchrotron (AGS) for both protons and heavy ions and as an accumulator and injector for polarized protons. Protons and polarized protons will be injected into the A/B ring at 200 MeV from the existing linac and accelerated to 1.0 GeV for injection into the AGS. Heavy ions will be injected into the A/B ring and accelerated to a maximum energy which depends on the particular heavy ion, then stripped and injected into the AGS. The transfer line to carry the heavy ions from the Tandem Van de Graaff to the AGS is under construction and will be finished during FY 1985.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

8. Brief Physical Description of Project

The Accumulator/Booster will have a circumference of 201 meters which is equal to 1/4 that of the AGS. This will allow efficient, synchronous bucket-to-bucket transfer of beam from the A/B ring to the AGS. The balance of the machine is designed with the objective of making it simple, relatively inexpensive, capable of accelerating protons to about 1 GeV, capable of accumulating polarized protons, and capable of accelerating heavy ions.

The lattice chosen is a FODO arrangement with bending magnets missing from every other cell. The Accumulator/Booster will utilize separated function magnets. This will minimize end effects in a lattice which has such a small packing factor. Magnetic field cycling requirements are up to 4 kG at 10 Hz rate for 1 GeV protons and 12 kG at 1 Hz rate for heavy ions. The heavy ion acceleration aspect is the determining constraint on the magnet specifications. The power supply requirements for both cases are almost identical. The tune and aperture of the ring are chosen to avoid depolarizing resonances, to match to the admittance of the AGS, and to be flexible enough to accommodate research and development of devices and techniques for the acceleration and storage of polarized protons. To cover the ion velocities of approximately 0.04 to 0.875 of the speed of light, the rf system consists of three cavities, one for protons and two for heavy ions, each covering a different frequence range.

The A/B ring will be housed in a ring building located in the vee formed by the junction of the 200 MeV linac building and the old 50 MeV linac building. This is very close to the AGS injection system and near the end of the transfer line from the Tandum. The existing 50 MeV linac building will serve as part of the A/B ring enclosure as well as house all power supplies necessary for this project. It will also serve as an assembly and staging area for ring elements prior to installation in the tunnel. Most of the ring will be located in a tunnel to be constructed north of the 50 MeV linac building, and two penetrations will enable the remaining 75-feet to be in the linac building itself. For most of the ring, the structural concrete and five feet of earth fill will provide the necessary radiation shielding.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

9. Purpose, Justification of Need for, and Scope of Project

The Accumulator/Booster will improve the performance and capabilities of the AGS for (1) normal proton operation, (2) operation with polarized protons and (3) operation with heavy ions. In each of these three modes of operation, the increased capability will have direct and immediate benefits by making accessible areas of science not previously accessible or by significantly increasing the data collection rate for the experimental program already planned and underway at the AGS.

(1) Normal Proton Research

When operating for normal proton research, the Accumulator/Booster will be used to accelerate protons to 1.0 GeV for injection into the AGS. At present injection is at 200 MeV. Injection at the higher energy will increase the space charge limit for the circulating beam and result in an increase of the extracted proton beam intensity by a factor of four to about 5×10^{13} protons per pulse.

For over two decades the Alternating Gradient Synchrotron has produced a steady flow of important physics, including major discoveries such as CP violation, the muon neutrino, the omega minus, the J/Psi, and the first charmed baryon. Today this machine is still the center of a vigorous research program, with experiments studying quantum chromodynamics via the search for glueballs and hard scattering exclusive reactions, searching for neutrino oscillations, and pushing the limits of the most complete theory, quantum electrodynamics, by measuring the vacuum polarization. In preparation are studies of extremely rare K decays via flavor changing neutral currents, which probe beyond the standard model to test very high energy theories like supersymmetry and technicolor. The increased beam intensity provided by the Accumulator/Booster will enhance this entire program but is of special importance to the rare K decay experiments.

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

9. Purpose, Justification of Need for, and Scope of Project (continued)

(2) Polarized Proton Research

When operating for polarized proton research, the Accumulator/Booster will be used to accumulate 20-30 linac pulses for subsequent injection into the AGS. This will increase the extracted polarized proton beam intensity by the same factor of 20-30. The polarized proton beam intensity which is available initially at the AGS will be adequate for the initial round of experiments, but the follow-on experiments will be limited by the available beam intensity. Much higher intensities are required to fully explore the physics of spin-dependent phenomena at AGS energies. The Accumulator/Booster, with the present polarized proton source, will result in a beam intensity of about 2×10^{11} protons per pulse.

The AGS has been modified to allow the acceleration of polarized protons. Initial research operation at low energy occurred late in FY 1984. The polarized proton beam intensity which is available initially at the AGS will be adequate for the initial round of experiments, but the follow-on experiments will be limited by the available beam intensity. The projected factor of 20 improvement will substantially improve the quality and cost effectiveness of the presently planned experimental program and allow consideration of new experiments where the increased beam intensity would be essential.

(3) Heavy Ion Research

When operating for heavy ion research, the Accumulator/Booster will accelerate partially stripped heavy ions from the existing Tandem Van de Graaff. The ions emerging from the Accumulator/Booster will have sufficient energy to allow them to be fully stripped with high efficiency before injection into the AGS. Because of the vacuum system considerations the AGS can only accelerate fully stripped heavy ions; the maximum energy available from the Tandem itself is such that only light ions (sulfur and below) can be fully stripped. The transfer line project which is presently underway will make available at the AGS beams of fully stripped high energy heavy ions up to sulfur. The Accumulator/Booster coupled with the Tandem will extend the heavy ion capability of the AGS to include heavy ions up to gold. The accelerated beam intensity of 2×10^{9}/pulse for Au, as an example, is a factor of 10^{5} greater than presently available at any other machine at energies greater than 1 GeV/amu. For the particular example of Au, the accelerated beam intensity is at the calculated space charge limit of the A/B ring.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

10. Details of Cost Estimate*

	Item Cost	Total Cost
a. Engineering, design and inspection at 31% of construction cost (17% of conventional construction and 33% of special facilities)	$	$ 5,100
b. Construction Cost		16,900
1. Conventional Construction	2,000	
Tunnel and utilities	$ 2,000	
2. Special Facilities and Accelerator Systems	14,900	
Magnets	5,500	
Magnet power supplies	2,600	
Other Systems	6,800	
c. Contingency at approximately 20% of above cost		4,400
Total estimated costs		$26,400

*Based on Completed Conceptual Design.

11. Method of Performance

Building design will be on the basis of a negotiated AE contract and its construction will be a competitively obtained lump sum contract. Design, assembly, and testing of the special facilities and accelerator system will be done by the staff of the Brookhaven National Laboratory. Component parts, wherever posible, will be fabricated by industry under fixed-priced competitively-obtained procurement actions.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

12. Funding Schedule of Project Funding and Other Related Funding Requirements

a. Total project costs	FY 1986	FY 1987	FY 1988	FY 1989	Total
1. Total facility costs					
(a) Construction line item.....	$ 1,100	$ 3,500	$12,100	$ 9,700	$26,400
Total facility costs.....	$ 1,100	$ 3,500	$12,100	$ 9,700	$26,400
2. Other project costs					
(a) R&D necessary to complete construction.....	200	200	100	0	500
Total other project costs.....	200	200	100	0	500
Total project costs (Item 1 & 2).....	$ 1,300	$ 3,700	$12,200	$ 9,700	$26,900

b. Other related annual funding requirements (in FY 1987 dollars)

1. Facility operating costs.....	$ 1,100
2. Capital equipment not related to construction.....	100
Total related annual funding requirements.....	$ 1,200

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: AGS Accumulator/Booster
Brookhaven National Laboratory
Upton, NY

2. Project No.: 86-R-105

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total Project Funding

1. Total facility costs

(a) Construction line item - explained in Items 8, 9 and 10.

2. Other project costs

(a) R&D necessary to complete construction - includes development of beam instrumentation, controls concepts and computer software at a cost of $500,000.

b. Total related annual funding requirements

1. Operating costs - There will be an annual requirement for additional FTE's with additional materials, supplies and support services associated with the physics program.

2. Capital equipment not related to construction but related to the programmatic effort in the facility - These equipment funds will provide continual utilization growth of the facility through the acquisition of: new detectors monitoring equipment, and controls improvement, and general purchase capital items for the operating program.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No.: 87-R-101

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 3rd Qtr. FY 1987

4. Date Construction ends: 2nd Qtr. FY 1989

5. Previous cost Estimate: none
   Less amount for PE&D: none
   Net cost estimate: none
   Date:

6. Current cost estimate: $11,500
   Less amount for PE&D: 0
   Net cost estimate: $11,500
   Date: May 1985

7. Financial Schedule

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1987	$11,500	$11,500	$11,500	$ 4,700
1988	0	0	0	5,900
1989	0	0	0	900

8. Brief Physical Description of Project

This project provides for a variety of minor modifications, improvements and additions to the major high energy particle accelerators, colliding beam devices and experimental facilities. Funds of this type are necessary on an annual basis to maintain and improve the effectiveness of these facilities. The funds requested, which represent less than 1 percent of the present value of the government's investment in these facilities, produce a substantial return in terms of more cost effective operation and greater research productivity.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No.: 87-R-101

8. Brief Physical Description of Project (continued)

The following are examples of the major items of work to be performed at the various locations:

Brookhaven National Laboratory..... $2,500,000

Funds are requested for modifications, improvements and additions to the Alternating Gradient Synchrotron (AGS) and its related experimental facilities. Items planned include: Replacement of preaccelerators with a high current RFQ accelerator; installation of a transverse and longitudinal damping system; upgrade of the linac injection system; upgrade of primary proton target stations for high intensity, beam shielding, and improvements to the AGS control system.

Fermi National Accelerator Laboratory..... $5,900,000

Funds requested are for modifications, improvements and additions to the Fermilab accelerator facilities (which includes the linear accelerator, booster synchrotron, main ring, Tevatron and antiproton source rings) and to the switchyard, beam lines, target facilities and experimental areas.

Modifications to the accelerator facilities are expected to include: Low beta magnet and power supply system improvements incorporating the improved superconducting materials now available; upgrade of the Cryogenic Accelerator including improved magnet and cryogenic systems; accelerator controls improvements to provide for more sophisticated control systems for the Accelerator complex, including the Linac, Booster, Main Ring, Tevatron and Anti-protron source; improved instrumentation to cope with the increased demands made on the accelerator system by antiprotron production, colliding beam operations and fixed target operations.

Modifications to the experimental facilities are expected to include: Upgrading of beam line diagnostics and control systems and beam line improvements including magnets, power supplies and enclosures to accommodate new beamlines and experiments; additional shielding for the secondary beam enclosures in the experimental area; provisions for secondary beam energy upgrade; and modifications to provide improved test beam facilities.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No.: 87-R-101

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center (SLAC)..... $3,100,000

Funds are requested for modifications, improvements and additions to the SLAC linear accelerator and PEP colliding beam facilities, and to the associated experimental facilities. Items now planned for FY 1987 include: Provide for replacement of sub-booster klystrons and associated modulators with microwave solid-state amplifiers; provide for extended linac quadrupole focusing to control emittance growth; improve steering and position monitors; improvements necessary to produce polarized electrons and control vertical and horizontal polarization; provide upgrades to instrumentation and control systems to improve operating efficiency.

9. Purpose, Justification of Need for, and Scope of Project

Accelerator improvements are essential on an annual basis to maintain the short term operating efficiency and reliability, and the research flexibility of the high energy accelerators, colliding beam systems and related experimental facilities, thereby maintaining or enhancing their level of scientific effectiveness and productivity. Research advances and facility requirements in high energy physics occur at a rapid pace; further, each research facility is a unique assemblage of very specialized, high technology components. Consequently, there is a continuing need to modify facilities, frequently on a short time scale, in response to research needs and to respond to problems that can affect the reliability, efficiency and economy of operation on a time scale shorter than the normal two-year budget cycle. The requested accelerator improvements and modifications will provide greater flexibility for experimental setups, increased performance levels, and increased serviceability, thereby decreasing facility downtime, improving the productivity, scientific effectiveness and cost effectiveness of the U.S. program in High Energy Physics.

Since needs and priorities may change, other subprojects may be substituted for some of those listed. Some of these will be located on non-Government owned property.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No.: 87-R-101

10. Details of Cost Estimate

a. Engineering, design and inspection and component assembly and installation	$11,500
Total Estimated Cost	$11,500

The estimated costs of the programs at each laboratory are preliminary and, in general, indicate the magnitude of each program.

11. Method of Performance

Design will be primarily by contractor staff. To the extent feasible, construction and procurement will be accomplished by fixed-price subcontracts awarded on the basis of competitive bidding.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
HIGH ENERGY PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General Plant projects, various locations

2. Project No.: 87-R-102

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date Construction ends: 2nd Qtr. FY 1989

5. Previous cost estimate: none
Date: none

6. Current cost estimate: $11,200
Less amount for PE&D: 0
Net cost estimate: $11,200
Date: May 1985

7. Financial Schedule

Fiscal Year	Obligations	Costs FY 1985	Costs FY 1986	Costs FY 1987	Costs After FY 1987
Prior Year Projects	XXXXXXX	$ 4,040	$ 2,300	$ 0	$ 0
1985	10,200	2,800	4,600	2,800	0
1986	9,957	0	2,100	4,800	3,057
1987	11,200	0	0	2,600	8,600
		$ 6,840	$ 9,000	$10,200	$11,657

8. Brief Physical Description of Project

These projects provide for the many miscellaneous alterations, additions, modifications, replacements, and non-major construction required at the Brookhaven National Laboratory, Fermi National Accelerator Laboratory and the Stanford Linear Accelerator Center facilities. GPP projects focus on the general laboratory facilities whereas AIP projects focus on the tec nical facilities.

The following are examples of the major items of work to be performed at the various locations:

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations 2. Project No.: 87-R-102

8. Brief Physical Description of Project (continued)

Brookhaven National Laboratory		$6,000
Building Addition - Alternating Gradient Synchrotron	$250	
Water Controls Upgrade - Alternating Gradient Synchrotron	200	
Storage Building Construction - Alternating Gradient Synchrotron	350	
Water System Improvements - Alternating Gradient Synchrotron	250	
Applied Science Laboratory Conversion	150	
Increased Power Supply to Experimental Laboratory	300	
Sanitary System Extension, Phase I	900	
Asbestos Removal, Various Facilities	800	
Construction of Safeguards and Emergency Services Building	500	
Closure for Former Waste Disposal Site	300	
Communication System Improvement	200	
Construction of Supply and Material Warehouse	900	
Replacement of Water Main, Phase II	600	
Various Projects (less than $100,000 each)	300	
Fermi National Accelerator Laboratory		$3,300
Main Ring Road Improvements	350	
Service Building Improvements	500	
Utility Improvements	450	
Addition to the Experimental Areas Operations Center	800	
Meson Detector Building Improvements	450	
Improvements to Industrial Buildings	500	
Various Projects (less than $100,000 each)	250	

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations 2. Project No.: 87-R-102

8. Brief Physical Description of Project (continued)

Stanford Linear Accelerator Center..... $1,900*

Stanford Positron Electron Asymmetric Ring trestle replacement.....	100
Replacement of heating, ventilating and air conditioning equipment.....	400
Replacement of hot water system piping.....	200
Replacement of roofing at major buildings.....	300
Addition to Main Control Building.....	900

*These projects will be constructed at the Stanford Linear Accelerator Center on non-Government owned property.

9. Purpose, Justification of Need for, and Scope of Project

General plant projects are required for the general maintenance, modification and improvement of the overall laboratory plant and include minor new construction, capital alterations and additions, and improvements to buildings and utility systems. These are short-term projects whose timely accomplishment is essential for maintaining the productivity, increasing the operational cost effectiveness, and ensuring that necessary support services are available to the research program at the DOE-owned facilities. Since it is difficult to detail the most urgently needed items in advance, a continuing evaluation of requirements and priorities may result in additions, deletions, and changes to the currently planned subprojects. No significant R&D program is anticipated as a prerequisite for design and construction of the subprojects under consideration.

The funds requested for FY 1987 are estimated as follows:

Brookhaven National Laboratory	$ 6,000
Fermi National Accelerator Laboratory	3,300
Stanford Linear Accelerator Center	1,900
Total Estimated Cost	$11,200

Since needs and priorities may change, other subprojects may be substituted for those listed and some of these may be located on non-Government owned property.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations 2. Project No.: 87-R-102

10. Details of Cost Estimate

See description, item 8. The estimated costs are preliminary and, in general, indicate the magnitude of each program. These costs include engineering, design and inspection.

11. Method of Performance

Design will be by contractor staff or on the basis of negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by firm fixed-price contracts and subcontracts on the basis of competitive bidding.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

GENERAL SCIENCE AND RESEARCH

NUCLEAR PHYSICS

GENERAL SCIENCE PROGRAM DIRECTION

VOLUME 4

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DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
NUCLEAR PHYSICS
GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Nuclear Physics (NP)					
Medium Energy Nuclear Physics					
Operating Expenses..	$ 73,810[a/]	$ 73,131	$ 73,131	$ 85,000	$+11,869
Subtotal.....	73,810	73,131	73,131	85,000	+11,869
Heavy Ion Nuclear Physics					
Operating Expenses..	49,008	50,150	50,150	63,700	+13,550
Subtotal.....	49,008	50,150	50,150	63,700	+13,550
Low Energy Nuclear Physics					
Operating Expenses..	13,322	12,087	12,087	15,700	+ 3,613
Subtotal.....	13,322	12,087	12,087	15,700	+ 3,613
Nuclear Theory					
Operating Expenses..	9,300	8,999	8,999	10,500	+ 1,501
Subtotal.....	9,300	8,999	8,999	10,500	+ 1,501
Capital Equipment.....	12,700	13,403	13,403	16,000	+ 2,597
Construction.....	23,300	6,702	6,702	33,300	+26,598
Total					
Operating Expenses....	145,440[c/]	144,367	144,367	174,900	+30,533
Capital Equipment.....	12,700	13,403	13,403	16,000	+ 2,597
Construction.....	23,300	6,702	6,702	33,300	+26,598
Nuclear Physics.....	$181,440[b/d/]	$164,472[d/e/f/]	$164,472	$224,200[d/]	$+59,728
Staffing Total FTE's	(Reference General Science Program Direction Decision Unit)				

Authorization: Section 209, Public Law 95-91.

a/ Includes $3,100,000 Defense Programs support of Clinton P. Anderson Meson Physics Facility (LAMPF) operations.
b/ FY 1985 total reflects a reduction of $835,000 for ADP general reduction.
c/ FY 1985 total does not include $1,425,000 transferred to the SBIR program.
d/ Totals reflect a reduction of $1,300,000 in FY 1985, $2,500,000 in FY 1986, and $2,700,000 in FY 1987 for management initiative savings.
e/ $100,000 has been transferred to Assistant Secretary for Environmental Safety and Health.
f/ Total reduced by $7,328,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer. (1)	General Reduction (2)	Management Initiatives (3)	Pay Cost Restoration (4)	FTE General Reduction (5)	Gramm-Rudman-Hollings (6)	ES&H Transfer/ Reprogramming (7)	Subtotal (8)	Comparability Adjustments (9)	Total (10)
Nuclear Physics (ER)										
Medium Energy Nuclear Physics										
Operating Expenses	76,450					-3,259	-60	73,131		73,131
Heavy Ion Nuclear Physics										
Operating Expenses	52,650	-225				-2,235	-40	50,150		50,150
Low Energy Nuclear Physics										
Operating Expenses	13,400	-775				-538		12,087		12,087
Nuclear Theory										
Operating Expenses	9,400					-401		8,999		8,999
Capital Expenses	14,000					-597		13,403		13,403
Construction	7,000					-298		6,702		6,702
Subtotal, Nuclear Physics	172,900	-1,000				-7,328	-100	164,472		164,472
General Reduction:										
Operating Expenses	-1,000	1,000								
Capital Equipment	0	0								
Construction	0	0								
Total, General Reductions	-1,000	1,000								
Management Initiatives:										
Operating Expenses										
Capital Equipment										
Construction										
Total, Management Initiatives										
Pay Restoration										
Use of Prior Year Balances (NP)										
Operating Expenses										
Capital Equipment										
Construction										
Total, Prior Year Bal. (NP)										

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS

(In thousands of dollars)

1986 Appropriation enacted	$171,800
1986 Gramm-Rudman reduction	- 7,328
1986 adjusted	$164,472
o Provide a cost-of-living increment to maintain a constant level of research activities and facility utilization	+ 9,870
o Implement Continuous Electron Beam Accelerator Facility (CEBAF) construction and continue R&D which supports the project	+26,180
o Using recently completed upgrade, conduct AGS heavy ion nuclear research program with 1000 beam hours for research and complete funding for initial complement of detectors	+ 7,150
o Provide for accelerator improvement and facility maintenance projects to meet programmatic needs and provide for general purpose equipment to meet laboratory-wide needs of Lawrence Berkeley Laboratory	+ 1,620
o Conduct program operations with overall facility utilization at 55% in FY 1987	+ 8,230
o Provide for university component of research at 25% of operating expenses and provide for internationally collaborative efforts in solar neutrino research	+ 4,058
o Conduct R&D in order to maintain U.S. leadership in accelerator technology	+ 2,620
1987 budget request	$224,200

Nuclear Physics

The Nuclear Physics program supports the basic research necessary to identify and understand the fundamental features of atomic nuclei and their interactions. Nuclear processes have guided the evolution of the universe, fueled solar burning, and determined the elemental composition of the earth. The nucleus is the arena of interplay of the primary forces of nature -- the strong nuclear force, the electromagnetic force, and the weak force. Nuclear studies continuously interact with other disciplines in order to maintain their currency in emerging problems. The study of nuclear physics consequently lies at the core of fundamental scientific research.

In terms of trained manpower, new knowledge, and advanced instrumentation, the Nuclear Physics program continues to be a vital factor in America's long-term investment in its technological future. Nuclear knowledge, techniques, instruments, and applications are an integral part of American society. These serve as the basis for our national defense strategy, for therapeutic and diagnostic medical applications, for generation of electricity with nuclear reactors (fission now and fusion in the future), and for a large and diverse array of applications in industry. Approximately 80% of the total Federal support of basic nuclear research is provided through the DOE Nuclear Physics program. Thus, the Department of Energy has the primary responsibility for this important area of basic science and its role in high technology.

The broad scope of the Nuclear Physics research program requires a variety of accelerator facilities, experimental equipment, and manpower skills. Different aspects of the questions being asked by scientists are addressed by beams of low energy light ions, heavy ions, electrons, medium energy protons, and relativistic (very high energy) heavy ions. Additional information is obtained by use of secondary beams (created by impinging primary beams on suitable targets) of neutrons, pi mesons (pions), K mesons (kaons), muons, photons, neutrinos, and radioactive nuclei. The new scientific challenges now facing basic nuclear research require advanced accelerators designed to provide the beams needed for the research.

The devices needed for detection of the products emitted in nuclear reactions also vary widely. At low energies, solid-state detectors made of germanium or silicon and scintillation counters using large transparent crystals are common. At higher energies, arrays of wire proportional chambers, drift chambers, plastic scintillator hodoscopes, and Cerenkov radiation detectors are used. At all energies, the use of magnetic spectrometers for measuring the momentum of charged particles is vital. A substantial R&D effort is devoted towards developing new detector techniques, and a significant commitment of resources is required to develop the new detectors which are essential to the success of planned experiments. However, in the final analysis, the most important ingredient for success is the continued presence of skilled and imaginative scientists -- experimentalists and theoreticians -- dedicated to solving the mysteries of the nucleus. The Nuclear Physics program relies upon a strong university component to provide scientists for basic nuclear research and to help meet America's need for manpower with high technology skills.

Long range planning, scientific community input, and coordination of Department of Energy work with National Science Foundation (NSF) activities will continue to take place through a variety of channels. The most important of these channels are external and internal review of specific research areas, frequent staff contact with counterparts at NSF, and the work of the DOE/NSF Nuclear Science Advisory Committee (NSAC).

Program Highlights

The body of knowledge in basic nuclear research has grown systematically over the years. Old problems have been resolved, and new questions have been asked. The path to new knowledge has had its share of surprises and frustrations. Sometimes the intractability of the problems has virtually stifled advancement. In other cases, a theoretical breakthrough or availability of new facilities or equipment has led to rapid progress. Advanced knowledge of nuclear structure has been enhanced by the availability of intense beams of polarized protons and deuterons. The use of polarized beams allows the determination of spin parameters of nuclear excitations in addition to knowledge of energies and decay modes. Sophisticated new gamma-ray spectrometers have been or are being installed at the Oak Ridge National Laboratory, at Argonne National Laboratory, and at the Lawrence Berkeley Laboratory's 88-Inch Cyclotron. These are leading to a new wealth of data on the mechanism by which nuclei become platter shaped when spinning at very high rates.

It has long been recognized that mesons, especially pions, provide the cement that holds nuclei together. Recent measurement of the rate of production of pions in high energy nucleus-nucleus collisions at the Lawrence Berkeley Laboratory's Bevalac has once again emphasized their omnipresent role. At the Bevalac, enhanced production of kaons and reduced production of pions tested the models of absorption of mesons in nuclear matter. The systematic study of the interaction of beams of free pions with nuclear targets at the Clinton P. Anderson Meson Physics Facility (LAMPF) at the Los Alamos National Laboratory has been a mainstay of the LAMPF program. In recent LAMPF experiments, pions have been used in double charge exchange measurements to explore new symmetries in nuclear excitations. At the Holifield Heavy Ion Research Facility (HHIRF) at Oak Ridge National Laboratory, pions have been detected emerging from nuclear collisions at beam energies far lower than previously believed possible. At the Massachusetts Institute of Technology's Bates Linear Accelerator Center, the delta particle (a close association of pions, protons, and neutrons) has been calculated to be a significant component of nuclei. And at Brookhaven National Laboratory's Alternating Gradient Synchrotron (AGS), beams of kaons have been used to make new states in hypernuclear images of conventional nuclei. The role of mesons as nuclear constituents and their utility as nuclear probes continues to be an important component of nuclear physics research.

Beyond the mesonic description however, new theoretical concepts are opening the door to a more profound level of understanding. Neutrons and protons are now described as composites of quarks and gluons, while mesons are composites of quark-antiquark pairs. Nuclear theorists, along with high energy theorists, are investigating the ways in which quarks are confined together in "bags" of three to make up neutrons and protons. A more fundamental theory of the nuclear force is emerging based on the quantum chromodynamics (QCD) model of quarks and gluons. This new theory alters in ever expanding ways the concepts and phenomena of nuclear physics. Exploring these concepts requires higher energies than have been available to the Nuclear Physics program. The theory provides a microscopic view of the way that mesons perform their binding function in nuclei. A glimpse into the role that quarks play in nuclei is being pursued using electron beams at the off-axis injector at the Stanford Linear Accelerator Center. The Continuous Electron Beam Accelerator Facility (CEBAF) is expressly designed to examine the transition region from pion-dominated to quark-dominated effects. It will generate precise beams of high energy electrons that will probe the quark structure of nucleons embedded in finite nuclei.

Another very different approach into the role of quarks in nuclei will be made possible by the Tandem/AGS Heavy Ion Transfer Line project at Brookhaven's AGS accelerator. This facility upgrade, scheduled for start of experiments in FY 1987, will allow the AGS to accelerate atomic nuclei to energies of up to 14 billion

electron volts per atomic mass unit (GeV/AMU). These beams will collide with massive nuclei at rest in the laboratory to produce hot, dense nuclear matter, relaxing the confinement conditions which prevent the quarks from escaping from their nucleonic bags.

At even higher energies, collisions of heavy ions would permit formation of a quark-gluon plasma, in which the quarks and gluons interact freely over the volume of the entire nucleus. Calculations simulating this plasma have been a major theoretical activity over the last few years. This plasma would create conditions in the laboratory which existed only a few millionths of a second after the "Big Bang" of creation. A preliminary glimpse into this area of physics will be provided by cooperative experiments at the CERN Laboratory in Geneva, Switzerland. In FY 1987, CERN plans two 17-day experimental running periods in which oxygen nuclei (16 atomic mass units) will be accelerated to energies up to 225 GeV/AMU. American scientists supported by the Nuclear Physics program are leaders in many of the experiments designed to capitalize on this window of opportunity.

Just as theory has made dramatic advances, so has the technology of accelerators and experiments improved. Superconducting linear accelerator elements have been designed, installed, and put into research use at the Argonne Tandem/Linac Accelerator System (ATLAS) at Argonne National Laboratory and are being installed at the University of Washington. New high-voltage capability is being installed at the Yale University tandem. A cyclotron using superconducting coils is being built at Texas A&M University using State of Texas funds and private Welch Foundation funds. A powerful, new electron-cyclotron resonance ion source at the Berkeley 88-Inch Cyclotron opens the way for acceleration of an extended range of heavy ion species, and an innovative metal vapor ion source at the Lawrence Berkeley Laboratory's SuperHILAC is providing a dramatic increase in the intensities of the heaviest nuclei. The program maintains a vigorous accelerator R&D effort to ensure that its facilities operate at maximum efficiency and scientific effectiveness.

Continuous Electron Beam Accelerator Facility

The highest priority for new construction in basic nuclear research in the United States is the Continuous Electron Beam Accelerator Facility (CEBAF). The FY 1987 request includes $25,000,000 for initiation of construction plus $6,250,000 in operating expense funds for continuation of supporting research and development. Total estimated cost of CEBAF construction is $236,000,000.

CEBAF will be a new, single-purpose facility for basic nuclear research. Its combination of continuous beam, high intensity, and high energy will be unique in the world. Thus, CEBAF's construction will be an important step in maintaining America's position of leadership in basic nuclear research. It will be operated as a user facility attracting a worldwide community of nuclear scientists. The central instrument of CEBAF will be a high intensity, high duty factor electron accelerator with an energy range of 0.5-4.0 billion electron volts (GeV). The construction project includes an initial complement of experimental equipment and support facilities necessary to perform scientific experiments using CEBAF's high-quality electron and photon beams.

Upon completion of construction, scientists can investigate the ways in which the quarks bound in neutrons and protons influence the makeup and behavior of nuclei, determine how quarks interact while embedded within nuclear matter, and test quantum chromodynamics as the fundamental theory of the strong nuclear force. Experiments in which electrons knock protons or neutrons out of nuclei will yield information about how energy and momentum is distributed among the nucleons (generic name for neutrons and protons) bound inside nuclei and will tell us about correlations among nucleons

in nuclei. At the high energy limit of electron scattering, experiments are, to a good approximation, only sensitive to effects of electrons scattering from individual quarks within the nuclei. Under these circumstances, nuclei can be described as a loose collection of free quarks. At energies below 1 GeV, electron scattering from nuclei can accurately be described as electrons scattering from the protons, neutrons, and mesons known to be in nuclei. The energy capability of CEBAF would permit quantitative examination of the transition between these complementary descriptions of nuclei.

The requested $25,000,000 in FY 1987 construction funds is essential for a timely construction project schedule. Specific FY 1987 construction activities will include: (1) acquisition of the Space Radiation Effects Laboratory building site in accordance with Executive Order 12348 and in compliance with regulation 41 CFR Part 101-47; (2) architectural and engineering work; (3) site preparation and utilities including AC power distribution equipment; (4) rehabilitation of existing structures; (5) start of construction on one of the tunnels which will house the linac; (6) engineering and design work on accelerator components, helium refrigerators, and cryogenic systems; and (7) acquisition of initial components of the accelerator. The requested $6,250,000 in operating expenses is necessary for continuation of work to optimize design of CEBAF's cryogenic and helium refrigerator systems, beam extraction systems, accelerator components, and control systems. FY 1987 research and development work will include fabrication and testing of prototypes of critical accelerator and cryogenic subsystems. Also, the FY 1987 R&D effort will include detailed planning for CEBAF's initial complement of research equipment.

Accelerator Facility Operations

The Nuclear Physics program requires the existence and effective operation of large and complex accelerator facilities. These facilities provide the variety of projectile beams upon which virtually all experimental nuclear research depends. Their capabilities determine which experiments can be performed.

Seven accelerator facilities are operated by the Nuclear Physics program as national facilities. These facilities are made available to all the nation's scientists on the basis of scientific merit and technical feasibility of proposals. These national facilities are: the Clinton P. Anderson Meson Physics Facility (LAMPF) at Los Alamos National Laboratory (LANL); the Bates Linear Accelerator Center at Massachusetts Institute of Technology (MIT); the SuperHILAC/Bevalac at Lawrence Berkeley Laboratory (LBL); the Holifield Heavy Ion Research Facility at Oak Ridge National Laboratory (ORNL); the 88-Inch Cyclotron at LBL; the Tandem/Linac Facility at Argonne National Laboratory (ANL); and the Double MP Tandem Van de Graaff facility at Brookhaven National Laboratory (BNL). The off-axis injector at the Stanford Linear Accelerator Center (SLAC) is now operational and serves the nation's scientists on the same basis as a national facility. Upon completion of the Tandem/AGS Heavy Ion Transfer Line construction project, heavy ion beams accelerated by BNL's Alternating Gradient Synchrotron (AGS) will also be available, beginning in FY 1987, on a national facility basis.

In addition to its internal research program, each of the national facilities accommodates major university-based user group research programs. Typically, an outside user group plans experiments, fabricates detectors and other instrumentation at the home institution, executes and partially analyzes experiments at the national facility, and then completes analyses and publication of results at the home institution. Nuclear Physics directly supports 70 university-based user groups who conduct most or all of their research at these national facilities.

To complement the national facilities, the Nuclear Physics program supports on-campus accelerators at Yale University, Duke University, University of Washington, and Texas A&M University. The Duke Cyclograaff serves a consortium of three universities (Duke University, University of North Carolina of Chapel Hill, and North Carolina State University) called the Triangle Universities Nuclear Laboratory. While each of the on-campus facilities has an important visitor program, these accelerators are operated principally for the research use of the host university's faculty, junior scientists, and graduate students.

In FY 1987, a total of $93,330,000 in operating expenses is requested for operation of accelerator facilities. In FY 1987, the national facilities are expected to have an overall utilization factor of 55%, approximately the same as in FY 1985. Within the FY 1987 accelerator operations total, $1,800,000 is budgeted for 900 beam hours of SLAC injector operations for nuclear research, and $8,670,000 is budgeted for AGS/Tandem facility operations. Also, in the FY 1987 operating expenses request, $71,070,000 is planned for experimental research and $10,500,000 for theoretical research. Within this experimental research total, $260,000 is budgeted for E. O. Lawrence ($60,000) and Enrico Fermi ($200,000) Awards.

Of the total FY 1987 operating expenses request, $44,372,000 is planned as direct support to the university program including university-based users of American and international facilities, accelerator operations and research at on-campus facilities (including MIT Bates), advanced accelerator technology research at MIT, continuation of research and development in support of the CEBAF construction project, and research by university-based theorists.

Additional support to the university program, in an amount comparable to the direct support, is provided through the accelerator centers in the form of services in support of experiments by university scientists and delivery of particle beams to these experiments. The Nuclear Physics program supports numerous research contracts in which there is substantial cost sharing by the universities. The universities' contributions are provided by a number of mechanisms -- for example, salaries to investigators, provision of work space, local machine shop time and labor, computer time, and equipment. The Nuclear Physics program encourages such cost sharing policies to achieve maximum utilization of available Federal funds.

	FY 1985	FY 1986	FY 1987 Request
Medium Energy Nuclear Physics	$ 73,810	$ 73,131	$ 85,000

The Medium Energy Nuclear Physics subprogram supports operations and research at accelerator facilities with sufficient primary beam energy to produce pi mesons (pions) using projectiles no more massive than alpha particles. In addition, the subprogram supports nuclear physics experiments at accelerators operated by other DOE programs (e.g., High Energy Physics and Basic Energy Sciences) and at other unique domestic or foreign facilities.

Two national accelerator facilities are operated entirely under the Medium Energy subprogram--the Clinton P. Anderson Meson Physics Facility (LAMPF) at Los Alamos National Laboratory and the Bates Linear Accelerator Center operated by the Massachusetts Institute of Technology. These accelerator facilities serve an international community of scientists including those from more than 100 American institutions, of which over 90% are universities.

Of the accelerators for which operations support is provided under Medium Energy, the largest nuclear physics program is carried out at LAMPF. The facility is centered around a linear accelerator which is capable of accelerating very intense beams of protons to 800 MeV. A primary role of this facility is to provide intense secondary beams of pions, muons, neutrons, and neutrinos. The ability to provide 10 or more simultaneously operating beams of protons, neutrons, pions, muons, or neutrinos enables LAMPF to be a highly cost-effective basic nuclear research facility. In addition to providing beams for nuclear research, LAMPF provides beams for basic materials research and weapons development at the Weapons Neutron Research (WNR) facility.

The other accelerator facility entirely supported under the Medium Energy subprogram is the Bates accelerator facility. The accelerator is capable of producing electron beams of excellent quality at energies up to 750 MeV. The Bates nuclear research program emphasizes high resolution nuclear structure studies with electrons and studies of the momentum distribution of neutrons and protons moving inside nuclei. Bates is the premier facility in the world for nuclear structure studies involving high resolution electron scattering.

The High Energy Physics electron accelerator at the Stanford Linear Accelerator Center (SLAC) is now also operated on a part-time basis for nuclear physics research using an off-axis source and injector. SLAC operations for nuclear research are supported under the Medium Energy subprogram. In FY 1987, 900 beam hours are planned for nuclear research.

Research activities in medium energy nuclear physics range over an extremely broad selection of topics, including studies of: the fundamental symmetries of nature; distribution of electric charge and magnetic fields inside nuclei; interactions of protons, mesons, and neutrons with nuclei; neutrino oscillations and the neutrino mass; interactions between nucleons; and nuclear structure.

An ultimate goal of all nuclear physics is a complete description of the fundamental particles and forces of nature. Recently, theoretical descriptions of the electromagnetic and weak forces have been unified. This means that these two seemingly disparate interactions have been shown to be different manifestations of the same, basic "electroweak" force. This represents a giant step along the road towards this ultimate goal.

The electroweak interaction actually has three manifestations: the familiar electromagnetic interaction, the charged weak interaction responsible for beta decay, and the neutral weak interaction recently discovered in neutrino scattering. One of the most striking predictions of the "standard model" of the electroweak interaction is that in the elastic scattering of electron-type neutrinos from electrons, the charged and neutral weak interactions will destructively interfere so that the probability of such scattering will be less than that expected if neutral weak interactions were not present. However, prior to a recent LAMPF experiment, the elastic scattering of electron-type neutrinos from electrons had not been observed, mostly because there have been no appropriate sources of these neutrinos. (Note that neutrino-electron elastic scattering is an extremely rare process.) At the LAMPF beam stop (a strong source of electron-type neutrinos), nuclear physicists mounted a large experiment to detect the elastic scattering and measure the interference. The detector is a 15-ton sandwich of scintillation counters and flash chambers specifically designed to detect the recoil electron from elastic scattering and to discriminate against background processes. During the first run of the experiment, 1.6×10^{19} neutrinos passed through the apparatus and 20 neutrino-electron elastic scattering events were detected. This number agrees with the standard model

prediction with destructive interference. This experiment paves the way for two other major neutrino experiments in preparation at LAMPF. In FY 1987, execution of neutrino experiments will have a high priority within the overall LAMPF research program.

The nuclear force between protons and neutrons (nucleons) in atomic nuclei has long been understood to be dominated by the exchange of bound mesons, with the pi-meson (or pion) being by far the most important in determining the nature of the nuclear force. Pions can also be produced in a free state, and their properties can be directly measured. When a free pion with an energy of a few hundred MeV interacts with a nucleon it often forms a new particle named the delta. The properties of these particles are well described within a theoretical framework of quarks and gluons; the nucleons contain three quarks each and the mesons are composed of quark-antiquark pairs. In this framework, the delta has a particularly simple structure, closely related to that of the nucleon; it consists of three quarks but with a simple rearrangement of quark spins. Introducing a free pion into an atomic nucleus thus can change the quark structure of that nucleus and permit the exploration of quark effects within the many-body nuclear system. Recent work by a collaboration of university and laboratory scientists using LAMPF has provided new information on how introduction of a pion into a nucleus modifies the quark structure of that nucleus. Earlier experiments had indicated that the introduction of the pion into the nuclear medium leads to two possible reaction processes. A free pion may be reemitted, in a process that seems to occur primarily in the outer fringes of the nucleus where a delta is formed on one of the nucleons and subsequently decays back into a nucleon and a pion. Alternatively, the pion may simply disappear, absorbed in the sea of bound pions in the nuclear medium, giving up its mass and energy to nuclear excitation. Such an absorption process also starts with a delta, perhaps in a region of higher nucleon density further inside the nucleus, where the delta interacts with other nucleons and eventually turns back into a nucleon without ever reemitting a free pion. It had been thought for a long time that, in an absorptive interaction, the delta would interact with only one other nucleon with the original energy of the pion eventually shared among only two final nucleons. The recent LAMPF work has shown that, in heavy nuclei, the number of nucleons participating in a pion absorption reaction is typically four. The quark substructure of nucleons is showing itself here, but a full explanation is just beginning to emerge. In FY 1987, investigations of the ways in which pions interact with nuclei and studies of the formation and motion of deltas inside nuclei will continue to be a major theme of LAMPF research.

The users of the facilities of the MIT-Bates Linear Accelerator Center are engaged in a systematic study of nuclear dynamics by exploiting the known properties of the electromagnetic field to probe the detailed behavior of nuclear charges and currents. The electromagnetic field is carried by high energy beams of electrons and photons of high intensity and precision to nuclear targets located in two principal experimental areas. The nuclear interactions are studied by means of a complex of magnetic and other spectrometer systems which detect the scattered electrons and photons and/or the reaction products which include protons, mesons, deuterons, and alpha particles. Systems to detect neutrons are in development. By selecting the energy of the incident beam and the direction, energy, and nature of the detected reaction products, it is possible to answer with great specificity questions about different aspects of nuclear dynamics. The data thus obtained provide the least ambiguous tests of and guidance for the development of nuclear theory. With the upgrade of experimental facilities at Bates, a whole new class of studies has begun. These are broadly distinguished by the detection of a strongly interacting particle in the final state, sometimes with an associated scattered electron. Whereas earlier studies were concerned primarily with the distribution in space of nuclear stationary states, these new programs are designed to study, among other properties, the

momentum distribution of nucleons moving inside nuclei. In a study of electron scattering from carbon nuclei, scientists working at Bates have observed significant departures from the expectations of a single nucleon knock-out picture and see evidence for correlated two-nucleon motion.

The best quantitative measurements for testing the theory that protons and neutrons are made up of quarks come from precision scattering experiments carried out with various high energy beams of electrons or muons. Results of these precision scattering experiments have given detailed information about the quarks and their motion inside the proton and neutron. Recently, the European Muon Collaboration (EMC) at CERN used muon beams to bombard nuclei spanning the periodic table from hydrogen to uranium. Researchers observed that the high energy muons scattered differently from the quarks bound inside nuclei than from the quarks in free protons and neutrons. This unexpected observation, called the EMC effect, has been verified with high precision by more recent work at CERN and at the Stanford Linear Accelerator Center. Several different theoretical models have been proposed to explain the EMC effect, such as (1) an increased size of the three-quark bag (nucleon) within the nucleus; (2) the existence of six-quark bags within the nucleus; (3) enhancement of the number of pions within the nucleus; and (4) conventional nuclear structure effects from momentum and binding energy distributions. Since each of these theoretical models can explain the existing electron and muon data, it is important to test with further experiments the differences identified in the various models. A set of complementary nuclear physics studies using medium energy and high energy particles as probes will investigate phenomena arising from the larger variety of configurations available to quarks in heavy nuclei as compared to configurations in individual nucleons.

In FY 1987, $85,000,000 in operating expenses is requested for the Medium Energy Nuclear Physics subprogram. The costs of facility operations at the LAMPF, Bevalac Bates, and SLAC facilities require 62% of the FY 1987 Medium Energy Nuclear Physics request. In addition to supporting the operation of the accelerators themselves, these operations costs also provide for the maintenance and operation of secondary beam lines, major spectrometer systems, and other permanently installed experimental equipment. The remaining 38% of the budget supports costs directly attributable to executing individual experiments, support of participating research scientists, R&D in support of the Continuous Electron Beam Accelerator Facility construction project, and advanced accelerator physics studies. Of the total operating expenses request in FY 1987, $25,285,000 will be for direct support of university research programs, including the Southeastern Universities Research Association (SURA). In addition, much indirect support is provided by the accelerator facilities at which much of this research is performed.

To operate the LAMPF facility in FY 1987, $42,920,000 is required. This total will permit LAMPF to operate 2800 beam hours for research. In addition to these operations costs, $10,900,000 is required for the conduct of research at LAMPF by Los Alamos scientists and by outside user groups, including university groups.

To operate Bates in FY 1987, $6,440,000 is required, and in addition $3,000,000 is required for the conduct of research at Bates by MIT scientists and outside user groups. Operation of the SLAC nuclear physics injector and associated experimental area requires $1,800,000 in FY 1987, with an additional $1,200,000 being budgeted for support of outside groups using the facility. R&D activities by SURA in support of the CEBAF project will require $6,250,000 in FY 1987.

Medium energy nuclear physics research, including the university component, using kaons from a separated secondary beam at the Brookhaven AGS will continue as an important component of this subprogram and will require $3,500,000 in operating

expenses in FY 1987. Other Medium Energy activities for FY 1987 include: research at unique foreign facilities; research using polarized, tagged photons at the National Synchrotron Light Source (NSLS); advanced accelerator research and development projects at the National Bureau of Standards, MIT, and LANL; and Fermi Awards. For these research activities, $8,990,000 is requested in FY 1987.

	FY 1985	FY 1986	FY 1987 Request
Heavy Ion Nuclear Physics	$ 49,008	$ 50,150	$ 63,700

The Heavy Ion subprogram supports accelerator facilities and research programs that cover a broad range of topics which are currently expanding our knowledge about the properties of nuclear matter. In combination, these facilities based at national laboratories and major universities provide beams of atomic nuclei ranging in mass from lithium to uranium and in energy from a few MeV to several hundred thousand MeV. In general, each accelerator complex provides beams and experimental facilities for in-house research groups as well as a nationwide community of scientists who travel to the host laboratory to conduct their research. The program makes use of unique properties of heavy ion beams for developing research in such diverse areas as microscopic nuclear properties, macroscopic nuclear interactions, and searches for exotic phases of nuclear matter predicted by theory.

In late FY 1986, the Tandem/AGS Heavy Ion Transfer Line construction project at Brookhaven National Laboratory (BNL) will be completed. In FY 1987, implementation of research programs to study relativistic heavy ion collisions with this new facility in a previously inaccessible energy regime is the highest priority in the Heavy Ion subprogram. The Transfer Line couples the BNL Tandem and Alternating Gradient Synchrotron (AGS) accelerators to provide heavy ion beams up to energies of 14 billion electron volts per atomic mass unit (GeV/AMU) for atomic nuclei up to mass 32 AMU (sulfur). This AGS/Tandem facility will provide beams approximately seven times more energetic than have been previously available anywhere in the world. Research programs in FY 1987 will allow scientists to enter the regime of energy and mass density which could lead to the production of states of nuclear matter which have never before been observed. In FY 1987, the development of detectors and experimental programs at BNL which were begun in FY 1985 will continue. First experiments will be performed during the 1000 hours of beam time planned for FY 1987. Effort will be given to the development of the accelerator complex so that it can provide the variety of beams with characteristics necessary to support the proposed research programs. Both the research and accelerator programs draw heavily on previous experience with heavy ions at lower energies and on experience from High Energy Physics programs. At Lawrence Berkeley Laboratory (LBL) a vigorous research program on heavy ion collisions will continue utilizing beams with masses up to 238 AMU (uranium) and energies up to 2.1 GeV/AMU from the SuperHILAC/Bevalac accelerator complex. The Bevalac remains unique in its capability for providing high energy beams of the heaviest nuclei.

Very active research programs utilizing lower energy heavy ion beams (5-25 MeV/AMU) are supported by complementary facilities at Argonne National Laboratory, Oak Ridge National Laboratory, and Lawrence Berkeley Laboratory (ANL, ORNL, and LBL). At ANL, the new ATLAS facility with its superconducting linac will begin full operation in FY 1986 and provide medium mass heavy ion beams with very precise energy and excellent time profiles for use in a new generation of experiments. The Holifield Heavy Ion Research Facility at ORNL is a state-of-the-art tandem accelerator (designed to achieve 25 million volts on the terminal) coupled with the Oak Ridge Isochronous Cyclotron. The Holifield facility provides precision beams and a wide variety of projectiles. The LBL 88-Inch Cyclotron supplies beams of light to medium mass heavy

ions. Its capabilities have been enhanced significantly by the recent addition of an Electron Cyclotron Resonance ion source. This source provides a broad selection of highly charged heavy ion species which can be accelerated to energies appropriate for nuclear studies. This facility is complementary to the tandem facilities because, unlike the ANL and ORNL facilities, the 88-Inch Cyclotron uses positive ions throughout its acceleration cycle. Each of these national laboratory-based accelerators is operated as a national facility. Access to machine time and experimental equipment is open to all qualified scientists on the basis of proposals reviewed for scientific merit and technical feasibility. In addition to the national laboratory accelerators, state-of-the-art facilities are shared with the Low Energy Nuclear Physics subprogram at three universities--Yale University, University of Washington, and Texas A&M University. Each of these accelerators provides a combination of light ion and heavy ion beams, and each of the three university facilities is being upgraded to provide additional research capability. These projects and the research that they will make possible are discussed under Low Energy Nuclear Physics.

The heavy ion beams from these accelerator facilities are used in a wide range of nuclear research programs. At one extreme, heavy ion reactions can produce a broad spectrum of nuclei with precise values of excitation energy and angular momentum for systematic studies of the properties of nuclei near their normal ground states. At another extreme, heavy ion collisions can produce for a brief instant small amounts of nuclear matter at temperatures and densities far from those of normal stable nuclei.

Many forefront spectroscopic studies of nuclear properties concentrate on experiments that measure the shapes of nuclei as their angular momentum and excitation energy are changed. This area is currently undergoing a renaissance as a result of major improvements in capabilities and sophistication of new gamma ray detection facilities. At ORNL, studies of the gamma ray decay of the Giant Quadrupole Resonance has led to new information on the shapes and structure of low-lying excited states in a variety of nuclei. These resonances correspond to a particularly simple class of nuclear excitations which arise from large scale oscillations of the nuclear surface. Precise studies of their decay modes give new insights into the underlying structure of the excited nuclei. Utilizing sophisticated new gamma ray detector arrays, scientists at LBL have been able to extend their studies of the nuclear shape transitions that occur at high spins, thus providing sensitive new tests for nuclear models.

Recent progress at Lawrence Berkeley Laboratory's Bevalac includes the first experimental determination of the compressibility of hot nuclear matter by studying the emission of pions from colliding nuclear systems. LBL scientists also made the first measurement of hydrodynamical flow effects in heavy ion collisions. Recent experiments have used the Plastic Ball detector to detect and measure over one hundred particles simultaneously emitted when nuclei accelerated to high energy collide with nuclei stationary in the laboratory. These programs mark the beginning of quantitative studies to determine the equation of state of hot, dense nuclear matter. Research of this type is essential for providing the overall framework within which experiments at higher energies can be planned and interpreted. Information on the equation of state for nuclear matter provides the input necessary to the theoretical models of stellar evolution leading to supernova explosions and neutron stars.

In FY 1987, the first particle beams with very high energies will become available at Brookhaven National Laboratory. Brookhaven's Tandem/AGS facility will deliver beams of nuclei as massive as sulfur (mass = 32 AMU) and with energies up to 14 GeV AMU. The extreme nuclear conditions created using these beams may yield the first

identifiable relaxation of the quark confinement conditions in nuclear matter. The first major heavy ion experiment at the Brookhaven facility is based on a single-arm magnetic spectrometer with high-multiplicity tracking and particle identification. Characteristics of hot dense nuclear matter will be obtained by measurement of effective temperatures and reaction cross sections. A second major experiment involves a Time Projection Chamber mounted in a large volume magnet. This system is designed to measure essentially all charged particles emerging from collisions to look for rare events that would indicate the onset of quark deconfinement.

At energies of tens of billions of electron volts per atomic mass unit and above, heavy ion central collisions may create an entirely new form of matter called a quark-gluon plasma. At sufficiently high temperatures and densities, it is expected that the nucleons which are the normal constituents of nuclei will dissolve into a plasma consisting of their internal substructures, the quarks and gluons. This plasma will then rapidly expand and decay into large numbers of more familiar nuclear constituents--nucleons and mesons. A vigorous theoretical effort is under way to specify the experimental signatures of this state of nuclear matter. These theoretical studies will guide experiments in distinguishing desired events from more prolific background processes. In addition to their value to basic nuclear research, present and planned research on properties of hot, dense nuclear plasmas are becoming increasingly relevant for understanding how our universe behaved in the first instants after the "Big Bang."

At the Super Proton Synchrotron (SPS) at CERN two 17 day running periods are planned with 50 GeV/AMU and 225 GeV/AMU beams of oxygen (16 AMU). Nuclear Physics-supported scientists are leading participants in several CERN experiments which are designed to get a first glimpse of the evidence of a phase transition of nuclear matter to a quark-gluon plasma. These new research efforts involve large collaborations involving university and national laboratory groups from the United States, Europe, and Japan and from both the Nuclear Physics and High Energy Physics communities.

The highest priority effort in FY 1987 in the Heavy Ion Nuclear Physics subprogram will be initiation of heavy ion nuclear research at the AGS. The Heavy Ion operating expenses request includes $8,670,000 for AGS/Tandem facility operations. Of the Heavy Ion total request, $25,680,000 supports research activities; the remaining $38,020,000 request is for facility operations. Also included is $2,000,000 for advanced accelerator R&D at Brookhaven National Laboratory for the heavy ion program. This accelerator R&D program is expected to define the parameters of a facility dedicated to production and examination of the quark-gluon plasma. Of the $25,680,000 request for research funds, $6,525,000 is planned as direct support to universities. Additional university support is provided through the national laboratories in the form of services in support of experiments and provision of beam time.

Of the $38,020,000 requested for accelerator facility operations, $18,540,000 is budgeted for operation of the Bevalac; $8,670,000 is requested for operation of Brookhaven's Tandem/AGS accelerator complex; and $9,315,000 is requested for operation of ATLAS, the 88-Inch Cyclotron, and Holifield. For heavy ion operations at accelerator facilities at Yale University, Texas A&M University, and the University of Washington, $1,495,000 is planned.

The accelerator facilities whose operations are supported by the Heavy Ion subprogram also provide unique capabilities for fundamental research in other fields of physics. Important recent examples include atomic physics studies of one-electron atoms for nuclei as heavy as uranium at the Bevalac and studies of the behavior of highly

ionized atoms at low velocities using a novel acceleration-deceleration mode with the two tandems at BNL. Nuclear fragmentation studies at the Bevalac are providing important data for the interpretation of cosmic-ray results. Heavy ion accelerator facilities also have important applications in biomedical research and human cancer therapy. Bevalac heavy ion beams are used to evaluate the effectiveness of heavy ions in destroying human cancer cells while doing minimum damage to intervening healthy cells. This research is supported and managed by the National Cancer Institute and the Department's Nuclear Medicine Applications subprogram in the Biological and Environmental Research programs. (All facility operations costs of the Bevalac, including those for biomedical research, however, are supported by the Nuclear Physics program.)

	FY 1985	FY 1986	FY 1987 Request
Low Energy Nuclear Physics	$ 13,322	$ 12,087	$ 15,700

This subprogram emphasizes experimental investigations of nuclear structure, nuclear decay parameters, and low energy reaction mechanisms. These studies also include general tests of fundamental theories and symmetries, as well as more specific and detailed studies of reactions involved in stellar and cosmologic processes.

University-based research is an important feature of the Low Energy subprogram. In FY 1987, 34% of operating expenses is planned for direct support of university research. FY 1987 marks the initiation of research programs based on major upgrades at each of Nuclear Physics' four dedicated on-campus accelerator facilities. These upgrades include major additions and improvements to the accelerator facilities at the University of Washington and Yale University, a new booster cyclotron at Texas A&M University, and high intensity polarized ion sources at Duke University and the University of Washington.

Nuclear research at the University of Washington will be greatly strengthened when the new superconducting linac booster becomes available in late FY 1987. The booster has been optimized for the acceleration of light ions and heavy ions up to about mass 60 AMU. The new polarized ion source will make possible a wide variety of high precision particle and photon asymmetry measurements for parity violation studies, electromagnetic multipole-mixing determinations, and those polarization measurements which are sensitive probes of nuclear reaction mechanisms. The booster will also make it possible to generate pulsed, monoenergetic neutron beams which can be used to study the E2 isovector giant resonance and other high-lying resonances in a variety of nuclei.

The upgrade of the Yale facility, scheduled for completion in September 1986, will provide an substantial increase in the range of ion energies and masses available for experiments. The anticipated maximum terminal voltage of 22.5 million volts will make it possible to study properties of much heavier nuclear systems with higher excitation energies and more angular momentum. To distinguish more precisely between electric and magnetic transitions in heavier nuclei, a mini-orange-type electron spectrometer is under development for on-line direct detection of conversion electrons. Yale also plans to construct a "silicon box" detector, consisting of a large solid-angle array of semiconductor charged-particle detectors, which will be used to study the excitation spectrum of heavy nuclei by coincidences between gamma rays.

Completion of the construction of a K=500 superconducting cyclotron at Texas A&M University late in 1986 will permit expansion of experimental capabilities there. The new cyclotron, whose construction has been funded by the State of Texas and the

private Welch Foundation, will be used alone or as a heavy-ion injector for the existing K=147 cyclotron. The energy range that will be made accessible by coupled operation of the two cyclotrons will provide unique opportunities at Texas A&M. For example, it will permit the production of a high-resolution polarized neutron beam in the 100-160 MeV range that can be used to investigate (n,p) charge exchange reactions and to determine Gamow-Teller matrix elements. They will emphasize nuclei that are candidates for double beta decay which provide sensitive tests of non-zero neutrino masses. These neutron beams will also be used to determine the parameters of neutron-proton scattering in the 80-160 MeV neutron energy region where few reliable measurements exist. The availability of higher energy alpha particle beams, 200-300 MeV, will greatly enhance studies of giant resonances and will permit the creation of rare, unstable nuclides that have not been available for studies heretofore.

The high-intensity polarized ion source at the Duke University accelerator facility will provide an increased intensity that can be used to great advantage in the current experimental program of measurements using polarized protons, deuterons, and polarized neutrons. Polarized neutron experiments, which use secondary beams of neutrons derived from reactions induced by polarized deuterons, will greatly benefit from the more intense beams of deuterons made available by the source. Especially enhanced will be the research using polarized neutrons incident on a cryogenic polarized target. The effects of neutron-nucleus spin-spin forces that are one of the main objects of study are predicted by nuclear theory to be much smaller than the spin-independent forces. Use of the new source should reduce running times for these experiments by a factor of 10. Tests of fundamental symmetries, such as parity conservation and time reversal invariance, are also planned using the polarized target and new polarized ion source.

The conversion of hydrogen to helium by nuclear fusion in the deep interior of the sun is believed to be the primary source of solar energy. Neutrinos are the only particles that escape directly from the solar interior, and thus they provide the only immediate probe of the deep interior of the sun. A unique experiment by Brookhaven scientists, employing a chlorine detector designed to measure the flux of neutrinos from the sun, discovered that the number of neutrino-induced events is about a factor of three lower than one expects from models that correctly reproduce other properties of the sun. This observation implies either that we do not have an adequate understanding of the nature of processes or conditions inside the sun, and hence of stellar processes in general, or that we do not have an adequate understanding of the neutrinos.

An August 1985 report of the NSAC Solar Neutrino subcommittee discussed several alternative experimental approaches for obtaining increased information, including the capture of neutrinos on gallium-71. International collaborative experiments are being formulated to resolve this solar neutrino puzzle.

The low-energy nuclear physics subprogram also supports light-ion research at the LBL 88-Inch Cyclotron, ORNL, and ATLAS. At the 88-Inch Cyclotron, light nuclei far from stability are studied with an on-line mass analysis system. Nuclear scientists are searching for nuclei near the proton and neutron limits of particle stability that may decay by new radioactivities such as beta-delayed two-proton decay. At Oak Ridge, physicists are investigating the mechanisms by which nuclei are excited into giant resonance states and the properties of giant resonance states. At ATLAS, research teams are using proton and other light-ion beams to determine electroweak interaction parameters in nuclei. For example, a high-precision measurement to study the vector-coupling coefficients in 0^+ to 0^+ Fermi decay will be undertaken using the reaction $^{10}B(p,n)^{10}C$.

In FY 1987, $15,700,000 in operating expenses is requested for the Low Energy subprogram. Of this total, $1,500,000 is requested for solar neutrino research and $4,285,000 is budgeted for research and operations at the four dedicated on-campus accelerator facilities to permit them to make productive use of their expanded capabilities. For other university-based research, $1,017,000 is requested. For low energy nuclear research and facility operations at the national laboratories, Small Business Innovation Research, and the Lawrence and Fermi Awards, $8,898,000 is requested in FY 1987.

	FY 1985	FY 1986	FY 1987 Request
Nuclear Theory	$ 9,300	$ 8,999	$ 10,500

Nuclear physics deals with phenomena submicroscopic in origin. It is therefore particularly dependent on theory for the interpretation of experimental results. More importantly, the field is motivated to consider many new exciting experimental possibilities based on the ideas generated and developed by theorists. Questions of how quark substructure of the nucleus might be manifested in experiments at the planned electron machine (CEBAF) or how a phase transition to the quark-gluon plasma would be seen in high energy heavy ion collisions are just two of the exciting new directions.

The Nuclear Theory subprogram is strongly interactive with all three experimental Nuclear Physics subprograms: Medium Energy, Heavy Ion, and Low Energy. Major theory efforts are supported in each of the institutions at which the Nuclear Physics program's national accelerator facilities are sited: Massachusetts Institute of Technology, Argonne National Laboratory, Brookhaven National Laboratory, Los Alamos National Laboratory, Lawrence Berkeley Laboratory, and Oak Ridge National Laboratory.

In addition, a larger number of theoretical nuclear physicists are supported at 28 universities across the nation. In FY 1987, $5,765,000, 55% of the total amount, is budgeted for direct support of university-based nuclear theory programs.

At the heart of much of nuclear theory research is the nuclear many-body problem. Although crucial breakthroughs that allowed the development of a theory of strong interactions occurred three decades ago, only recently have the technical difficulties been sufficiently overcome to allow separation of two-body and three-body effects in nuclear matter calculations. This achievement occurred through years of development of mathematical techniques by theorists, and through the increasing access to supercomputers by the nuclear theory community. In FY 1985 over 1000 hours of supercomputer time was made available at the MFE Computer Center at Livermore by Energy Research's Office of Scientific Computing for nuclear physics research, and more than 2500 hours will be available at Livermore and at SCRI at Florida State University in FY 1986.

Special relativity has been found to play a much more important role in nuclear matter and proton-nucleus scattering than previously expected. Recent results in nuclear theory show that, even at low energies, the traditional nonrelativistic nucleon-nucleus potential may be better described in terms of a relativistic theory. Effects of very-short-lived particle-antiparticle pairs are new phenomena predicted by the relativistic theory. These effects are especially important in the calculation of antiprotons as they react with stable nuclei. Another rapidly developing aspect of nuclear-matter theory relates to nuclear astrophysics. Knowledge of the nuclear equation of state, in particular the compressibility of nuclear matter, determines our ability to understand collapsing stars as they consume all of their nuclear fuel. Astrophysical calculations require that nuclei have a

"soft" equation of state (very easily compressed) in order to bounce back from a gravitationally driven implosion, creating a shock wave that may lead to a supernova explosion. Results from high energy heavy ion collisions, however, indicate that nuclear matter is very "hard." This disparity leads to a distinct, unresolved scientific dilemma.

Attempts to understand how quarks, gluons, and their interactions determine the makeup and behavior of nuclei will be a central theme of nuclear theory in FY 1987. The basic underlying theory of quarks is known to be quantumchromodynamics (QCD) but the implementation of this theory in the prediction of properties of nuclei is challenging. In all experiments so far, quarks have been found together only in triplets or in quark-antiquark pairs, never alone. The theoretical implication of that experimental result is that quarks are confined and can never be isolated. An outstanding problem of nuclear and high-energy theory is how to generate such a confining force from QCD. Current development of quark models incorporating phenomenological confinement provides physical insight and suggests that a full quark description of nuclei will eventually be obtained. Nuclear theorists bring their particular expertise in many-body physics to the problem of understanding how the behavior of quarks in a nucleus of many nucleons differs from the behavior of quarks in a single neutron or proton.

A recent intriguing result from nuclear theory is that at sufficiently high temperature and pressure a nucleus can change character from being primarily triplets of quarks confined within nucleons into a quark-gluon phase. The entire nucleus becomes, in effect, the confining region, with the quarks released from the individual nucleon to form a "quark-gluon plasma." Such a transition is predicted to occur in nucleus-nucleus (heavy ion) reactions at sufficiently high energy. One problem that is currently challenging theorists is to determine an experimental signature of the phase transition from nuclear matter to a quark-gluon plasma.

In FY 1987, $10,500,000 in operating expenses is required for Nuclear Theory to provide the essential underpinning of theory for the new experimental initiatives discussed earlier in the Medium Energy, Heavy Ion, and Low Energy subprograms. New and basic theoretical developments can point the way to new experiments and complex experimental results must be interpreted and understood in terms of fundamental theory. Development of QCD into a precise, quantitative description of the strong nuclear force, and then into a quantitative description of nuclear interactions and structure is indeed a worthy challenge to nuclear theorists.

	FY 1985	FY 1986	FY 1987 Request
Capital Equipment	$ 12,700	$ 13,403	$ 16,000

Capital equipment funds are needed to provide for instrumentation to improve performance of Nuclear Physics accelerators for particle detection systems, and for data acquisition and analysis systems. These funds are essential for effective utilization of the national accelerator facilities operated by the Nuclear Physics program. In FY 1987, $14,770,000 in programmatic capital equipment funds is required for Nuclear Physics research initiatives and for maintenance of the overall productivity of the Nuclear Physics program. In addition, $1,230,000 is requested for general purpose equipment at Lawrence Berkeley Laboratory (LBL), for which the Nuclear Physics program has laboratory-wide landlord responsibility. Of the $14,770,000 requested for programmatic capital equipment, $4,600,000 is requested for Brookhaven National Laboratory (BNL), primarily in support of heavy ion nuclear research at the AGS; $2,630,000 is requested for Los Alamos National Laboratory (LANL) in support of LAMPF experiments and accelerator operations; and $2,840,000 is

planned for experiments and operations at the Lawrence Berkeley Laboratory (Bevalac and 88-Inch Cyclotron). The remaining $4,700,000 is budgeted for the ATLAS facility at Argonne National Laboratory (ANL), the Bates Linear Accelerator Center at the Massachusetts Institute of Technology (MIT), the Holifield Heavy Ion Research Facility at Oak Ridge National Laboratory (ORNL), and Nuclear Physics programs at Duke University and the Stanford Linear Accelerator Center (SLAC).

Nuclear physics research requires carefully prepared beams of protons, neutrons, antiprotons, pions, kaons, muons, photons, electrons, and massive nuclei (such as oxygen, sulfur, iron, gold, and uranium). Detection and interpretation of the results of collisions of these probes with target nuclei requires scientific instrumentation at the limits of present day technology. In addition, the new scientific questions being asked are more discerning and thus require experiments of greater sophistication. An example of this occurs in the field of relativistic heavy ion nuclear physics, where large, fine-grained detector systems must be constructed to confront the complexity of energetic heavy ion reactions in which hundreds of fragments are produced in a single collision.

At Brookhaven National Laboratory, the Tandem/AGS Heavy Ion Transfer Line construction project is creating the opportunity for an exciting experimental program with 14 GeV/AMU beams of heavy ions. Particle beams as massive as sulfur (32 atomic mass units) will be available in late FY 1986 from the Alternating Gradient Synchrotron. Two complementary large experiments have been approved for running. These experiments are designed to provide the first broad look at the physics with 14 GeV/AMU heavy ion beams at the AGS. One of them utilizes a single-arm magnetic spectrometer with high-multiplicity tracking chambers and particle identification detectors. The primary goal is to determine effective temperatures reached in central nucleus-nucleus collisions and to measure particle production cross sections in the forward hemisphere. The funding of this system (Total Estimated Cost = $4,200,000) will be completed in FY 1987. The second major approved experiment utilizes a time projection chamber mounted in the existing Multi-Particle Spectrometer magnet. The objective of this experiment is to measure all charged particles emerging from central collisions of nuclei. Anomalous behavior will be searched for in the observables as an indication of quark deconfinement effects. Completion of funding for this $1,300,000 experimental system is planned for FY 1987.

At Los Alamos National Laboratory, a neutron time-of-flight facility (TEC = $900,000; $550,000 in prior years and $350,000 in FY 1987) and a magnetic spectrometer (TEC = $1,100,000; $500,000 in FY 1986 and $600,000 in FY 1987) are needed as part of an expanded inelastic nucleon-nucleon scattering research program. These improvements will make possible a complete determination of the isospin-zero nucleon-nucleon scattering amplitudes as a function of energy and angle.

At Lawrence Berkeley Laboratory, a large solid-angle detector for the products of energetic heavy ion collisions is needed. The main physics thrust of this detector will be the study of central heavy ion collisions up to the highest Bevalac energies. With this device, the equation of state of nuclear matter can be well studied, since it will be possible to measure simultaneously many interesting hydrodynamic properties of nuclear matter, such as compressibility and thermal conductivity at high pressures and temperatures. A system based on a time projection chamber in conjunction with a time-of-flight array is planned. The device (TEC = $2,100,000; $300,000 in FY 1986 and $1,800,000 in FY 1987) will permit complete event reconstruction, enable the acquisition of data with good statistics since it can operate at high data rates, allow particle identification for protons, pions, kaons, and lambdas, and have good two-particle separation.

At Argonne National Laboratory, the MIT/Bates Linear Accelerator Center, Oak Ridge National Laboratory, and the Stanford Linear Accelerator Center, capital equipment funds are requested for a variety of needs which include high performance gamma-ray detectors, high pressure gas targets, spectrometer magnets and detector systems, the upgrading of computer systems for data acquisition and analysis, and for small equipment items for the operation of the accelerator facilities. Completion of funding for a high-intensity polarized ion source at the Triangle Universities Nuclear Laboratory (Duke University) is planned for FY 1987.

The Nuclear Physics program has responsibility for providing all of Lawrence Berkeley Laboratory's general purpose equipment. For efficient operation of the Laboratory plant and for personnel safety, obsolete equipment must be replaced on a continuing basis. In FY 1987, $1,230,000 is requested for all capital equipment that is required at this laboratory and is not specific to any one program. Examples include: spectrum analyzers and corona detectors for the electronics engineering group, film thickness measuring instruments for the mechanical shops, equipment for Computer-Aided Engineering, radiation detection equipment for LBL's environmental health and safety service groups, a UNIX 16-user work station for the information services group, a precision crane-load positioner for the plant and facilities group, and high-speed nonimpact printer systems for the accounting and financial management group.

	FY 1985	FY 1986	FY 1987 Request
Construction	$ 23,300	$ 6,702	$ 33,300

The total FY 1987 request for construction funds for Nuclear Physics is $33,300,000.

Nuclear Physics
Summary of Construction
(Dollars in Thousands)

Project Title	Project Number	FY 1987 Request	Total Estimated Cost
Continuous Electron Beam Accelerator Facility	87-R-203	$ 25,000	$236,000
Accelerator Improvements and Modifications	87-R-201	4,300	4,300
General Plant Projects	87-R-202	4,000	4,000
Total		$ 33,300	

Authorization and appropriation are requested to initiate construction of the Continuous Electron Beam Accelerator Facility (CEBAF). Research and development and A/E activities for the CEBAF project are now under way to better define the project's scope, schedule, and total cost. This effort will provide the technical base necessary for initiation of construction on a cost effective schedule in FY 1987. The CEBAF project is the highest priority construction project for basic nuclear research in the United States. CEBAF's unique combination of continuous beam, high intensity, and high energy will provide the opportunity for studying the largely unexplored transition between the nucleon-meson and quark-gluon descriptions of the nuclear force. Accelerator Improvement and General Plant funds are required in FY 1987 in order to meet the demands of frontier nuclear research, to improve efficiency of facility operations, and to maintain high standards of personnel safety.

Continuous Electron Beam Accelerator Facility

In FY 1987, $25,000,000 is requested to start construction of CEBAF. Upon completion CEBAF will feature an electron accelerator complex capable of delivering intense, continuous beams in the energy range from 0.5 to 4.0 billion electron volts (GeV). The intensity, energy range, and continuous nature of CEBAF's beams will make this facility unmatched in the world.

The accelerator complex will consist of: a 1 GeV superconducting linear accelerator (linac) which is split into two 0.5 GeV segments; a beam transport system to guide the electron beams from one segment to the other for up to four complete passes of acceleration through the linac to attain a maximum energy of 4 GeV at a design beam current of 200 microamperes; cryogenic systems and refrigerators to support operation of the superconducting linac; a beam transport system to deliver the continuous beams of electrons from the linac to the experimental halls; and instrumentation and control systems for the accelerator complex. The accelerator will service three independent experimental areas--two buildings for experiments using high intensity electron beams and a smaller area primarily designed for experiments using photon beams.

The conventional construction needed for the facility will include tunnels to house the superconducting linac, beam transport systems, and beam extraction systems; buildings for accelerator operations, cryogenic support systems, helium refrigerator systems, experimental areas, and general office/light laboratory space; beam dumps; and utilities. General office, laboratory, and shop space will also be provided by rehabilitation of existing structures.

In addition to the accelerator complex and buildings to house the research activities, this project will also provide an initial complement of experimental equipment to exploit the capabilities of the accelerator. This equipment includes several large spectrometers, and data acquisition and analysis computers.

FY 1987 activities will include: acquisition of the Space Radiation Effects Laboratory site; rehabilitation of existing structures to provide space for fabrication and testing of prototypes; site preparation and utilities extension; detailed design of accelerator components, helium refrigerators, and cryogenic systems; architectural and engineering work; start of construction on one of the tunnels which will house the linac; and acquisition of long lead components of the accelerator. To avoid delays in later years in installation and testing of accelerator components, these activities should occur in FY 1987.

Accelerator Improvements and Modifications

Accelerator facilities have continuous need during their operating life for small modifications or upgrades to enhance their performance for research use and to improve reliability and efficiency of operation. In FY 1987, a total of $4,300,000 is requested or these activities under Accelerator Improvements and Modifications.

At Argonne National Laboratory, $950,000 is requested for a new positive ion injector for the ATLAS facility. This injector, which uses a new type of superconducting resonator, will provide increased beam current, will improve operating reliability of the facility, and will provide heavier mass heavy ions to begin research in the area of quantum electrodynamics.

At Brookhaven National Laboratory, $500,000 is requested for a new AGS beam line to transport heavy ion beams from the accelerator to experimental stations. This new beam line will have the high vacuum capability and sensitive instrumentation necessary for heavy ion nuclear research.

At the Lawrence Berkeley Laboratory, $1,000,000 is needed for projects at the SuperHILAC/ Bevalac and the 88-Inch Cyclotron. On the SuperHILAC, drift-tube quadrupole magnets will be replaced. These have been damaged from running at the high fields needed to focus very heavy ion beams such as uranium. A second project is an intensity upgrade of the Electron Cyclotron Resonance ion source at the 88-Inch Cyclotron. This will be accomplished by raising the microwave frequency of the source from 6.4 to 14 GHz and increasing the microwave power level.

At Los Alamos National Laboratory, $1,500,000 is requested for LAMPF. Work will include final installation of an optically pumped polarized proton source and improvements of beam lines in the Nuclear Physics Laboratory so that high priority nucleon-nucleon scattering experiments can be conducted with polarized beams.

At the Bates Linear Accelerator Center, $350,000 is budgeted for two projects which are part of the polarized electron beam experimental program: a high voltage supply for the polarized source and a device for on-line measurement of beam polarization in the experimental area.

General Plant Projects

The Construction request includes $4,000,000 for General Plant Projects (GPP) at the Lawrence Berkeley Laboratory, the Bates Linear Accelerator Center at MIT, and the LAMPF facility at Los Alamos National Laboratory. At these laboratories, the Nuclear Physics program has responsibility for GPP funds which provide for minor conventional construction such as building additions and alterations, and other improvements as well as improvements to land and utility systems. A total of $2,600,000 is requested for projects at the Lawrence Berkeley Laboratory, including the replacement of an emergency power system, replacement of roofs on three buildings, building additions for light labs, and major electrical equipment replacement. At the LAMPF facility, $970,000 is planned for additions and improvements to the Nuclear Physics Laboratory for nucleon-nucleon scattering experiments and to the beam stop for weak interaction experiments with neutrinos. At Bates, $430,000 is requested to complete the upgrade of the accelerator cooling system and a microwave link to the MIT campus computers.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 87-R-201

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date construction ends: 2nd Qtr. FY 1989

5. Previous cost estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date:

6. Current cost estimate: $4,300
Less amount for PE&D: 0
Net cost estimate: $4,300
Date: 5/85

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Costs
1987	$ 4,300	$ 4,300	$ 4,300	$ 3,000
1988	0	0	0	1,100
1989	0	0	0	200

8. Brief Physical Description of Project

This project provides for additions, modifications, and improvements to major research accelerators and ancillary experimental facilities. The requested funds are necessary to maintain and improve reliability and efficiency of operations and to provide new experimental capabilities as required for execution of planned research programs.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 87-R-201

8. Brief Physical Description of Project (continued)

Listed below are the laboratories and a description of each subproject:

Argonne National Laboratory (ATLAS)..... $ 950

A positive ion injector will be installed at the Argonne Tandem/Linac Accelerator System (ATLAS) facility. The injector will utilize a completely new type of superconducting resonator especially developed to accelerate very-low-velocity ions and will provide 3 million volts of acceleration. An associated cryogenic system and beam line are part of the project.

Brookhaven National Laboratory (AGS/Tandem)..... $ 500

This subproject provides for a new AGS beam line for heavy ion experiments. Dipole and quadrupole magnets, vacuum systems, shielding, security gates, and highly sensitive beam instrumentation are included in the project.

Lawrence Berkeley Laboratory (SuperHILAC/Bevalac, 88-Inch Cyclotron)..... $ 1,000

This subproject provides for the replacement of about one-third of the drift-tube quadrupole magnets in the prestripper section of the SuperHILAC. The new quadrupoles will use a new technology based on rare-earth permanent magnets. These magnets will have 20% greater focusing strength than existing quadrupole magnets.

Also, the Electron Cyclotron Resonance (ECR) source at the 88-Inch Cyclotron will be upgraded by raising its operating frequency from 6.4 GHz to 14 GHz. New solenoid magnets and a new octupole magnet will be constructed and installed; a 14 GHz klystron will be installed.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 87-R-201

8. Brief Physical Description of Project (continued)

Los Alamos National Laboratory (LAMPF)..... $ 1,500

This subproject provides for the installation of an optically pumped polarized proton source in the Clinton P. Anderson Meson Physics Facility's injector room. This new source has a peak intensity of nearly 100 times that of the existing Lamb-shift source.

Additions and revisions to the permanent proton beam lines in the Nucleon Physics Laboratory are provided for by this project. These include a four-magnet beam swinger system at the time-of-flight facility which will permit variation of the incident angle of the proton beam and a new proton beam line to service the new Medium Resolution Spectrometer.

Massachusetts Institute of Technology (Bates Linear Accelerator Center) ..... $ 350

An Isolation Core Transformer is needed to power the new polarized electron source at Bates. Also, for the polarized electron beam program, construction of a Moller spectrometer in Bates' South Hall is planned.

9. Purpose, Justification of Need for, and Scope of Project

Argonne National Laboratory (ATLAS)

The new positive ion injector will increase the beam intensities and provide better operational reliability for almost all ion species now accelerated by ATLAS. The intensity increase will be especially great (100 times) for projectiles such as the calcium isotopes that are difficult to produce with the present tandem injector.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 87-R-201

9. Purpose, Justification of Need for, and Scope of Project (continued)

Brookhaven National Laboratory (AGS/Tandem)

The new AGS beam line will transport heavy ion beams from the accelerator to experiment stations. It will have the high vacuum capability and sensitive instrumentation necessary for heavy ion nuclear research.

Lawrence Berkeley Laboratory (SuperHILAC/Bevalac, 88-Inch Cyclotron)

A major limitation in the ability of the SuperHILAC to transport high mass beams efficiently is the loss rate due to damaged quadrupoles in the prestripper section. The existing drift tube quadrupoles were originally designed to provide the highest field gradients possible with the then-current (1970) technology. Since the addition of the ABLE injector these magnets have been run at the highest possible current levels to transmit the high mass beams (e.g., gold, uranium). This has resulted in an increased failure rate for the aged magnets and reduced transmission through the SuperHILAC for the highest mass beams by about 50%.

The higher RF frequency in the Electron Cyclotron Resonance ion source at the 88-Inch Cyclotron will allow efficient coupling of microwave power to higher density plasmas and is expected to increase the intensity of the very high charge state ions such as Ne10+ and Ar16+. Making higher charge states with sufficient intensity will significantly increase the energies of heavy ion beams from the cyclotron.

Los Alamos National Laboratory (LAMPF)

The optically pumped polarized proton source and improvement of beam lines in the Nucleon Physics Laboratory will provide capability for execution of high priority neutron-proton and proton-proton scattering experiments.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Accelerator improvements and modifications, various locations

2. Project No. 87-R-201

9. Purpose, Justification of Need for, and Scope of Project (continued)

Massachusetts Institute of Technology (Bates Linear Accelerator Center)

The Isolation Core Transformer now powering the polarized source is on loan and a permanent one is needed. Before coincidence measurements can be performed in the South Hall, it is necessary to be able to determine the beam polarization as it is delivered on target. Use of a Moller spectrometer is a convenient and conventional method for obtaining this information.

Since needs and priorities may change, other subprojects may be substituted for those listed and some of these may be located on non-Government owned land.

10. Details of Cost Estimate

a. Engineering, design, inspection, construction, procurement, component assembly, and installation	$ 4,300
Total Estimated Cost	$ 4,300

11. Method of Performance

Design will be by contractor staff. To the extent feasible, construction and procurement will be accomplished by fixed-price subcontractor awarded on the basis of competitive bidding.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS

(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General plant projects
various locations

2. Project No. 87-R-202

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 2nd Qtr. FY 1987

4. Date construction ends: 2nd Qtr. FY 1989

5. Previous cost estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date:

6. Current cost estimate: $4,000
Less amount for PE&D: 0
Net cost estimate: $4,000
Date: 5/85

7. Financial Schedule

Fiscal Year	Obligations	Costs FY 1985	FY 1986	FY 1987	After FY 1987
Prior Year Projects	xxx	$ 2,300	$ 100	$ 0	$ 0
1985	$ 3,500	800	1,700	1,000	0
1986	3,351	0	800	1,000	1,551
1987	4,000	0	0	1,000	3,000
		$ 3,100	$ 2,600	$ 3,000	$ 4,551

8. Brief Physical Description of Project

This project provides for minor new construction, other capital alterations and additions, and for improvements to land, buildings, and utility systems. Where applicable, the request also includes the cost of installed capital equipment integral to a subproject. No significant R&D program is anticipated as a prerequisite for design and construction.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations

2. Project No. 87-R-202

8. Brief Physical Description of Project (continued)

Lawrence Berkeley Laboratory ..... $ 2,600

Requirements include: Replacement of the emergency power system in the Building 50 complex; replacement of roofs on Buildings 70A, 77 and 88; extension of the service yard adjacent to Building 77; an addition to Building 74 for light labs; new switching station, feeder cables, and reconfiguration of emergency power switching for the Upper Hill area; and replacement of PCB insulated transformers in Buildings 50A and 50B. The Lawrence Berkeley Laboratory (Berkeley, California) is located on non-Government owned property.

Los Alamos National Laboratory (Clinton P. Anderson Meson Physics Facility)..... $ 970

This project includes improvements to the LAMPF Nucleon Physics Laboratory to prepare for an expanded experimental program involving the new, high-intensity polarized beam. Specific requirements include: a new floor, additional cooling water and electrical power, added radiation shielding, a counting area to service a new magnetic spectrometer, and a longer flight path and new shielding for the neutron time-of-flight facility. Also, minor additions to and modifications of the main beam stop are needed for conduct of neutrino experiments.

Massachusetts Institute of Technology (Bates Linear Accelerator Center) ..... $ 430

Requirements include: Upgrade of the accelerator cooling system by replacement of a deteriorated evaporative cooler and a microwave link between the Bates and the MIT campus computers to permit higher data transmission rates. The Bates Linear Accelerator Center (Middleton, Massachusetts) is located on non-Government owned property.

9. Purpose, Justification of Need for, and Scope of Project

Projects at the Lawrence Berkeley Laboratory, the LAMPF facility at Los Alamos National Laboratory, and at the Bates Linear Accelerator Center at the Massachusetts Institute of Technology are needed to improve efficiency and productivity of these installations and to assure continuation of safe and reliable operations for both personnel and instrumentation.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects
various locations

2. Project No. 87-R-202

9. Purpose, Justification of Need for, and Scope of Project (continued)

The distribution of funds requested for FY 1987 is as follows:

Lawrence Berkeley Laboratory	$ 2,600
Los Alamos National Laboratory (Anderson Meson Physics Facility)	970
Massachusetts Institute of Technology (Bates Linear Accelerator Center)	430
Total Estimated Cost	$ 4,000

Since needs and priorities may change, other subprojects may be substituted for those listed and some of these may be located on non-Government owned property.

10. Details of Cost Estimate

See description, item 8. The estimated costs are preliminary and, in general, indicate the magnitude of each program. These costs include engineering, design, and inspection.

11. Method of Performance

Design will be by contractor staff or on the basis of negotiated architect-engineer contracts. To the extent feasible, construction and procurement will be accomplished by firm fixed-price contracts and subcontracts on the basis of competitive bidding.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
GENERAL SCIENCE AND RESEARCH
NUCLEAR PHYSICS
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

3. Date A-E work initiated: 2nd Qtr. FY 1985

3a. Date Physical Construction Start: 2nd Qtr. FY 1987

4. Date Construction Ends: 2nd Qtr. FY 1992

5. Previous Cost Estimate: None
Less amount for PE&D: None
Net cost estimate: None
Date:

6. Current cost estimate: $236,300
Less amount for PE&D: 300
Net cost estimate: $236,000*
Date: 12/85

7. Financial Schedule:

Fiscal Year	Authorization	Appropriations	Obligations	Cost
FY 1987	$236,000	$ 25,000	$ 25,000	$ 14,000
FY 1988	0	65,000	65,000	42,000
FY 1989	0	65,000	65,000	56,000
FY 1990	0	55,000	55,000	58,000
FY 1991	0	26,000	26,000	45,000
FY 1992	0		0	21,000

8. Brief Physical Description of Project

The Continuous Electron Beam Accelerator Facility (CEBAF) is a single purpose, basic nuclear research facility to be located in Newport News, Virginia on a site which includes the land and buildings once occupied by the Space Radiation Effects Laboratory (SREL). Southeastern Universities Research Association (SURA) is expected to be the operating contractor during design, construction, and later operations phases of this project. The site for this facility will be Federally owned.

* Cost estimate based on December 1985 preconceptual design report.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

The accelerator facility will include: a 4 billion electron volt (GeV), high intensity, recirculated continuous beam electron linear accelerator (linac); experimental areas and equipment to conduct basic nuclear research; and buildings to house the accelerator complex and its operations and maintenance activities. The facility will possess a complement of equipment for initial experiments and supporting facilities to exploit the capabilities of the accelerator.

a) Improvements to Land and Conventional Construction

Improvements to the site will include such items as drainage, roadways, and the extension of utilities. Support facilities for the accelerator complex will be housed in both new and existing structures. The Virginia Associated Research Center (VARC), an existing single-story structure located on an adjacent site owned by the Commonwealth of Virginia, will provide research and administrative offices. Title to VARC will remain with the Commonwealth of Virginia, which by agreement has made it available to SURA indefinitely for CEBAF use. The Space Radiation Effects Laboratory building, will be renovated to provide shop areas, component test and assembly areas, laboratories, and office space. Support structures include: (1) housing for the linac, recirculator magnets, and beam lines and (2) buildings for the end stations, refrigerator, control center, and accelerator service functions. The SREL buildings and a surrounding 10 acre site will be acquired in accordance with Executive Order 12348 and implementing regulation 41 CFR 101-47.

b) Accelerator System

The central research tool of CEBAF will be an electron linear accelerator. It will consist of a 1 GeV superconducting linear accelerator split into two segments. The segments will be connected by a recirculator system to transport the electron beams from one segment of the linac to the other. Four complete passes of acceleration through the linac will provide an energy of 4 GeV. The accelerator complex will also include a beam extraction system to extract three continuous beams from the linac; a beam transport system to take the three beams to three experimental halls; a cryogenic system including helium refrigerator, liquid helium storage vessels, and distribution lines; and instrumentation and control systems for the accelerator complex.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

8. Brief Physical Description of Project (continued)

c) Research Equipment

The accelerator will service three independent experimental areas. Research equipment will include an initial complement of experimental instrumentation and other support facilities necessary to perform scientific research using CEBAF's high quality electron beams and secondary photon beams.

9. Purpose, Justification of Need for, and Scope of Project

CEBAF will be the only facility in the world capable of producing electron beams which simultaneously meet the criteria of high energy, continuous beams, and high intensity necessary to advance the frontiers of electromagnetic nuclear physics. CEBAF has been identified as the highest priority new accelerator for the U.S. nuclear physics program. The unique combination of beam parameters available at CEBAF will make it a facility of unparalleled capability, and the research at CEBAF will enable the U.S. to maintain its preeminence in this important area of nuclear science. CEBAF's electron linac, with its capability of providing intense continuous beams at any energy in the range of 0.5 to 4.0 GeV, is designed to study the largely unexplored transition between the nucleon-meson and the quark-gluon descriptions of nuclear matter. In particular, it will study the extent to which individual nucleons change their size, shape, and quark structure in the nuclear medium, study how nucleons cluster in the nuclear medium, and study the force which binds quarks into nucleons and nuclei at distances where this force is strong and the quark confinement mechanism is important. CEBAF's continuous beam will make it possible to observe one or more of the reaction products in coincidence with the scattered electron, ensuring that these studies can be carried out accurately. The broad spectrum of physics accessible at CEBAF ensures that it will become and remain one of the important scientific centers in the world.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

10. Details of Cost Estimate*

		Item Cost	Total Cost
a. Engineering, Design, Inspection, and Administration.....			$ 38,300
1. Conventional Construction at approximately 22% of item b.2		$ 10,800	
2. Technical components at approximately 28% of item b.3 ...		27,500	
b. Construction Costs.....			148,900
1. Land and Land Rights (Acquisition of the SREL site).....		1,700	
2. Conventional Construction.....		49,800	
a. Accelerator facilities.....	$ 8,600		
b. Experimental facilities.....	15,300		
c. Support facilities.....	10,200		
d. Utilities and site preparation.....	15,700		
3. Technical components.....		97,400	
a. Accelerator components.....	67,000		
b. Research equipment.....	30,400		
c. Standard Equipment.....			1,900
			189,100
d. Contingency at approximately 25% of above costs, excluding item b.1			46,900
Total Estimated Cost.....			$236,000

* Cost estimate based on December 1985 preconceptual design report.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

11. Method of Performance

Design, construction, and inspection of the facility will be done by the Operating Contractor, subcontracting with an A/E contractor for design and a general contractor for construction of the conventional facilities. To the extent feasible, construction, procurement, and installation will be accomplished by fixed-price contracts and subcontracts awarded on the basis of competitive bidding.

12. Funding Schedule of Project Funding and Other Related Funding Requirements

	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	Future Years	Total
a. Total project cost								
1. Total facility cost								
a. Construction line item.....	$ 0	$ 0	$ 0	$14,000	$42,000	$56,000	$124,000	$236,000
b. PE&D.....	0	300	0	0	0	0	0	300
Total facility cost.....	$ 0	$ 300	$ 0	$14,000	$42,000	$56,000	$124,000	$236,300
2. Other project costs								
R&D necessary to complete construction...	$ 1,000	$ 3,500	$ 4,787	$ 6,250	$ 6,213	$ 4,500	$ 0	$ 26,250
Total other project costs..	$ 1,000	$ 3,500	$ 4,787	$ 6,250	$ 6,213	$ 4,500	$ 0	$ 26,250
Total project cost.....	$ 1,000	$ 3,800	$ 4,787	$20,250	$48,213	$60,500	$124,000	$262,550

CONSTRUCTION PROJECT DATA SHEETS

1. Title and Location of Project: Continuous Electron Beam Accelerator Facility; Newport News, Virginia

2. Project No. 87-R-203

12. Funding Schedule of Project Funding and Other Related Funding Requirements (continued)

b. Other related funding requirements (FY 1986 dollars)

1. Annual facility operating costs including in-house research	$ 27,000
2. Annual plant and capital equipment costs not related to construction but related to the programmatic effort in the facility	4,000
Total other related annual funding requirements	$ 31,000

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements

a. Total project cost

1. Total facility cost
   Explained in items 8, 9, and 10
2. Other projects costs
   R&D necessary to complete construction

The CEBAF linac will use superconducting radiofrequency accelerating cavity technology to generate high energy continuous electron beams. The R&D funds will be used to design, evaluate, and construct prototypes of the technical components which are essential for meeting the design goals for the facility.

b. Other related funding requirements

1. Annual facility operating costs upon completion of construction

This item includes the cost of all personnel employed by the facility for its operation, maintenance, and in-house research, together with electric power and materials and services costs. Approximately 230 man-years of effort annually will be required.

2. Annual plant and capital equipment costs upon completion of construction

This item includes capital equipment needed to maintain the research capability of the facility to meet evolving research requirements as well as funds for accelerator improvement projects and minor general plant projects required to ensure its continued high performance.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
GENERAL SCIENCE PROGRAM DIRECTION
GENERAL SCIENCE AND RESEARCH
(Tabular dollars in thousands. Narrative material in whole dollars.)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
General Science Program Direction					
Operating Expenses...	$ 2,205	$ 2,092 a/ b/	$ 2,092	$ 2,500 a/	$ +408
Total.....	$ 2,205 a/	$ 2,092 a/ b/	$ 2,092	$ 2,500 a/	$ +408
Staffing Total FTE's..	37	39	39	39	

a/ Totals reflect a reduction of $5,000 in FY 1985, $15,000 in FY 1986, and $25,000 in FY 1987 for management initiative savings.
b/ Total reduced by $102,000 in accordance with P.L. 99-177, the Balanced Budget and Emergency Deficit Control Act of 1985 (Gramm/Rudman/Hollings).

Authorization: Section 209, P.L. 95-91.

DEPARTMENT OF ENERGY
1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
GENERAL SCIENCE PROGRAM DIRECTION
(In thousands of dollars)

1986 Appropriation enacted.....	$ 2,194
1986 Gramm-Rudman reduction.....	- 102
1986 adjusted.....	$ 2,092
Program increases and decreases:	
o Funding required to maintain FTE level	+ 408
1987 budget request.....	$ 2,500

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer. (1)	General Reduction (2)	Management Initiatives (3)	Pay Cost Restoration (4)	FTE General Reduction (5)	Gramm-Rudman-Hollings (6)	ES&H Transfer/ Reprogramming (7)	Subtotal (8)	Comparability Adjustments (9)	Total (10)
General Science Program Direction										
Operating Expenses	$ 2,400				$ -206	$ -102		$ 2,092		$ 2,092
Subtotal, General Science Program Direction.....	2,400				-206	-102		2,092		2,092
General Reduction										
Management Initiatives										
Pay Restoration										
Use of Prior Year Balances (GSPD)										
Use of Prior Year Balances (Other General Science)										
Total, General Science Program Direction.....	$ 2,400				-206	$ -102		$ 2,092		$ 2,092

General Science Program Direction

The FY 1987 request for General Science Program Direction is $2,500,000. These funds are required to provide for the personnel and other costs associated with continuation of 39 full-time equivalents. These funds support the staff in the Office of the Associate Director for High Energy and Nuclear Physics, the Division of High Energy Physics, the Division of Nuclear Physics, and associated support staff required to administer these programs.

The staff budgeted under this program is responsible for providing effective management, planning and direction to ensure that a viable, high quality national program of basic research and supporting advanced technology R&D is carried out in the fields of high energy physics and nuclear physics. To carry out these responsibilities, the staffs assess the basic research needs in these areas with advice from the appropriate advisory committees, the High Energy Physics Advisory Panel (HEPAP) and the DOE/NSF Nuclear Science Advisory Committee (NSAC). The DOE staff participates actively in both HEPAP and NSAC meetings and special subpanel studies and provides administrative support for their operation. (NOTE: Administrative support responsibility for NSAC is rotated between NSF and DOE; DOE staff has administrative responsibility again in FY 1986 and FY 1987.)

The staff develops and coordinates with appropriate agency and external communities a coherent policy and long-range plan for support of balanced national programs in high energy and nuclear physics; develops budget requests and justification for funding to implement program plans; optimizes the allocation of resources to the laboratories and universities supported by the Department to achieve maximum research productivity, cost effectiveness and efficiency of operation; provides technical oversight for high energy and nuclear physics research programs of 15 major laboratories and about 200 university contractors; and provides technical and project management oversight for three major construction projects.

Effective oversight of high energy and nuclear physics activities requires staff participation in formal annual on-site program reviews of contractors; semiannual on-site reviews of major projects; meetings of laboratory program advisory committees; special facility and research planning meetings; and regional, national, and international research meetings and technical workshops. The staff also participates extensively in international cooperative efforts, which involve the development and management of activities under three formal agreements for cooperation, including participation of U.S. scientists both in experiments at foreign facilities with unique capabilities not available in the U.S. and in conferences and workshops abroad.

The High Energy Physics staff oversees the operation of three large, complex high energy accelerator centers at BNL, Fermilab, and SLAC which are used by qualified physicists from throughout the Nation. The staff will provide technical oversight for the AGS Accumulator/Booster at BNL ($26,400,000 TEC). The upgrade of Fermilab's central computing capability ($23,900,000 TEC), which is essential for effective exploration of Tevatron physics, will continue. Two new world-class facilities, the Tevatron collider at Fermilab and the Stanford Linear Collider at SLAC, will begin their first year of operation for research in FY 1987. The staff will provide technical oversight for the operation of existing facilities and for startup of operation of the new capabilities available from the startup of the Tevatron and SLC. It will provide management oversight for fabrication of two large colliding beam detectors (approximately $40,000,000 each) for more effective utilization of the new Tevatron and SLC research capabilities.

The High Energy Physics staff manages more than 100 university research tasks, and the number is increasing. The staff also oversees an extensive program in advanced technology R&D including activities in support of ongoing construction projects, activities related to enhancing scientific capability and operating effectiveness of existing facilities, and studies of advanced concepts. This includes advanced accelerator R&D for future facilities.

Success of the Nuclear Physics program depends upon effective operation of seven large and complex national accelerator facilities. Nuclear Physics staff will continue to oversee high priority, new research capabilities at BNL (Tandem/AGS Heavy Ion Transfer Line), SLAC (off-axis injector), and ANL (ATLAS Construction Project). The University of Washington and Yale University will begin using the new enhanced capabilities of the University Accelerator Upgrade Project. The HENP staff will also be responsible for managing R&D associated with the Continuous Electron Beam Accelerator Facility, with construction planned to be initiated in FY 1987 at Newport News, Virginia. This project will be built by a consortium of universities unfamiliar with Departmental construction procedures. Staff work will also be required to respond to the large number of inquiries directly related to CEBAF and for briefings of senior staff of Congressional Committees, OMB, and OSTP, as well as members of Congress. In addition the staff must conduct monthly project reviews, review and monitor the actual construction activity, and monitor the design and acquisition of the experimental devices so that they are ready when the facility makes the transition from a construction project to an operating research facility. Nuclear Physics staff will also manage a university-based user program and a theory program to support the CEBAF electron scattering programs and the new heavy ion capabilities at BNL. Workload involving the theory program will include controlling use of time to be made available for theory calculations on a large computer, including review of proposals at LANL and LLNL, and evaluation of the needs of theorists for smaller on-site computers. The Nuclear Physics staff manages more than 100 university research tasks covering a very broad and diverse range of activities. The Nuclear Physics program staff also manages the Nuclear Data activity which is budgeted under Basic Energy Sciences.

In addition to the program-specific activities above, the Office of High Energy and Nuclear Physics is continuing to be impacted by increased emphasis on international collaboration, cooperative programs and formal agreements with foreign countries, which result in heavy workload and travel requirements. This, together with site visits required for day-to-day management activities, advisory committee activities, and other outside conferences and programmatic interfaces, places substantial burdens on the small Federal staff available for managing these large and complex programs. The Department of Energy provides over 90 percent of the Federal support and serves as the Executive Agent for the national High Energy Physics program. Approximately 80 percent of the total Federal support of basic nuclear research is provided through the Nuclear Physics program.

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

URANIUM ENRICHMENT

VOLUME 4

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DEPARTMENT OF ENERGY

Proposed Appropriation Language

Uranium Supply and Enrichment Activities

[For expenses of the Department of Energy in connection with operating expenses; the purchase, construction, and acquisition of plant and capital equipment and other expenses incidental thereto necessary for uranium supply and enrichment activities in carrying out the purposes of the Department of Energy Organization Act (Public Law 95-91), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion; purchase of passenger motor vehicles (not to exceed 34 for replacement only); $1,612,700,000, to remain available until expended: Provided, That revenues received by the Department for the enrichment of uranium and estimated to total $1,612,700,000 in fiscal year 1986, shall be retained and used for the specific purpose of offsetting costs incurred by the Department in providing uranium enrichment service activities as authorized by section 201 of Public Law 95-238, notwithstanding the provisions of section 3302(b) of 31 U.S.C. 484: Provided further, That the sum herein appropriated shall be reduced as uranium enrichment revenues are received during fiscal year 1986 so as to result in a final fiscal year 1986 appropriation estimated at not more than $0.]

As authorized by section 111(h) of Public Law 93-438, as amended, revenues received from the enrichment of uranium shall be credited to this account, to remain available until expended, and to be used for expenses of energy activities in connection with operating expenses, the purchase, construction and acquisition of plant and capital equipment and other expenses incidental thereto necessary for uranium supply and enrichment activities in carrying out the purposes of Public Law 95-91, or successor legislation, including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion; purchase of passenger motor vehicles (not to exceed 33 for replacement only): Provided, That obligations thus incurred may not exceed $1,051,400,000: Provided further, That within these limits, obligations may be incurred in advance of uranium enrichment revenues and shall be liquidated from such collections: Provided further, That of the revenues credited to this account, $235,000,000 shall be transferred to the general fund of the Treasury in partial repayment of Government investment in uranium supply and enrichment activities. (Public Law 99-141, making appropriations for enery and water development, 1986.)

DEPARTMENT OF ENERGY

FISCAL YEAR 1987 CONGRESSIONAL BUDGET REQUEST

SUMMARY OF ESTIMATES BY APPROPRIATION BY MAJOR ACTIVITY

URANIUM ENRICHMENT

BUDGET AUTHORITY IN THOUSANDS OF DOLLARS

	FY 1985 Actual	FY 1986 Estimate	FY 1987 Request
Uranium Enrichment Activities	$ 1,644,892	1,546,350	1,281,600
Program Direction	4,000	4,036	4,800
Subtotal, Uranium Enrichment	1,648,892	1,550,386	1,286,400
Revenues	-1,410,936	-1,360,600	-1,286,400
Less Use of Prior Balances and Other Adjustments	---	726	---
Total, Uranium Enrichment	$ 237,956	$ 190,512	$ ---

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
PROGRAM OVERVIEW
URANIUM ENRICHMENT

Uranium Enrichment Activities

The goal of the uranium enrichment activities program is to meet commercial and Government requirements for uranium enrichment services in the most economical, reliable, safe, secure, and environmentally acceptable manner possible.

The requested budget for the uranium enrichment activities program is $1,051,400,000. Through the sale of enriched uranium from existing inventories and rigorous cost reductions, this budget projects payment to the Treasury of $235,000,000. With the expectation of commercial and Defense Program revenues totaling $1,286,400,000, the net uranium enrichment appropriation request for FY 1987 is $0. It reflects the activities believed to be essential to allow the Department to remain competitive with other primary suppliers and thus retain a secure indigenous fuel supply capability to support the nuclear energy option and vital defense requirements in the United States.

The Department presently enriches uranium to the desired uranium-235 (U-235) product assay levels in its gaseous diffusion plants (GDPs) located at Portsmouth, Ohio and Paducah, Kentucky. These plants were built in the 1950s to satisfy defense requirements for highly enriched U-235. They are now operated primarily to provide commercial enrichment services to domestic and non-U.S. utility customers. In these plants, the Department enriches customer-provided natural uranium in the U-235 component for a fee that recovers the cost of providing the services. The Department is the sole producer of enrichment services in the United States. The specific statutory authority that established this role is the Atomic Energy Act of 1954, as amended.

The Department's uranium enrichment objectives are: (1) to be responsive to the needs of the Department's customers for enrichment services; (2) to provide a long-term reliable supply of separative work units (SWU) at predictable prices; (3) to achieve the lowest reasonable price based on sound business practices and utilization of advanced technologies; and (4) to recover costs and to operate the Government's enrichment complex without Federal subsidy.

The Department's strategies to meet these objectives are: (1) to bring supply and demand of DOE-origin enriched uranium into balance; (2) to offer reliable customer services; (3) to offer competitive prices; (4) to capture uncommitted market consistent with financial interests; (5) to minimize the cost of operating existing enrichment plants; (6) to transfer development and ultimate deployment of the Atomic Vapor Laser Isotope Separation (AVLIS) technology to the private sector; and (7) to adopt a more businesslike institutional structure for the future. These strategies are intended to enhance the soundness of the enterprise, and to provide the basis for transforming the program into a more competitive operation.

In the near term, the low operating levels of the GDP complex require power purchases substantially below existing contract levels. Therefore, the Department must pay capacity charges to its power suppliers for power not purchased to the extent that efforts to negotiate reduced contract levels are unsuccessful. In FY 1987 these capacity charges for power not purchased, primarily to the Tennessee Valley Authority, are estimated to be $454,000,000, or about 43 percent of the budget authority requested for programmatic activities. In FY 1987 the complex will operate at about 2,095 megawatts and produce about 7.6 million SWU. Customer requirements in excess of this amount will be withdrawn from existing inventories.

In FY 1987, activities related to maintaining the Oak Ridge GDP in a standby condition will continue. The Oak Ridge GDP will be maintained in a standby condition with Defense Programs providing the standby funding because of projected Defense demand for enrichment services in the outyears. If the standby funding is not provided, the Oak Ridge GDP will be permanently shut down. If the plant is permanently shut down, it will not be operable because critical components will not be maintained. In FY 1987, activities related to closing out the Advanced Gas Centrifuge (AGC) technology program, and terminating the Gas Centrifuge Enrichment Plant (GCEP) project will be largely completed. A small number of AGC and GCEP termination activities may not be completed until FY 1988.

The FY 1985 accomplishments and anticipated FY 1986 accomplishments include:

- Produced about 10.4 million SWU in FY 1985 and expect to produce about 7.6 million SWU in FY 1986.
- Initiated placement of the Oak Ridge GDP in a standby mode in FY 1985 to achieve savings of approximately $250,000,000 over the FY 1986-1991 timeframe.
- Maximized purchase of lowest cost firm power and initiated large-scale purchase of unfirm power at the GDPs in FY 1985 with resultant 13 percent decrease in average cost of power over FY 1984.
- Captured nearly 87 percent of our customers' uncommitted enrichment requirements through a creative marginal cost/incentive pricing offer.
- Selected the AVLIS technology for further demonstration and possible deployment to assure the long-term competitiveness of the uranium enrichment enterprise.
- Demonstrated four color photoionization and predicted rates of enrichment in a half-scale AVLIS demonstration facility.
- Demonstrated 100 hours (25 percent of prototypic plant life) of continuous operation of the near full-scale AVLIS Materials Handling Demonstration Module (MHDM).
- Integrated the one-half scale MARS separator with the first phase of the Laser Demonstration Facility in FY 1985. These facilities will be used in FY 1986 to demonstrate significant rates of enrichment for extended times to demonstrate the materials handling capability of this separator subsystem.
- Initiated closeout of the AGC program in FY 1985.
- Initiated GCEP termination in FY 1985.
- Began study of alternative uses for GCEP and AGC facilities.
- Initiated efforts to stimulate private sector interest and funding in the development and ultimate deployment of the AVLIS technology in FY 1986.
- The involvement of Martin Marietta Energy Systems in the AVLIS program will be significantly reduced in FY 1987 consistent with the completion of the beneficial use of MHDM, the need to operate the program at minimum cost and the program objective of seeking private sector participation.

The near-term program objectives for FY 1987 through FY 1991 are:

- Produce about 7.6 million SWU in FY 1987.
- Determine appropriate options and initiatives to meet commercial and U.S. Government demand reliably at minimum cost.

- o Transfer AVLIS to the private sector for further development.

FY 1987 is basically a period during which the restructuring of the uranium enrichment program that began in FY 1984 will be continued. The program changes have required dramatic alterations in our previous approach to research and development, production, and investment in new capacity. Implementation of the changes in the program have been painful, but as the implementation is continued in FY 1987, the enterprise will be in a strong position to compete effectively, into the 21st century.

In summary, the principal objective of the uranium enrichment enterprise in FY 1987 is to conduct all activities in a manner that maximizes near-term and long-term competitiveness. Competition in the international uranium enrichment marketplace is becoming increasingly more intense, placing increased emphasis on the need to reduce program costs and selling prices. Principal emphasis is being put on lowering prices, minimizing the production cost for the GDP complex, and on transferring future development of AVLIS to the private sector. Activities in the program will also continue to closeout the GCEP project and the AGC program at minimum cost to maintain the GDP located at Oak Ridge, Tennesee in a standby condition.

Payment to Treasury

The Department of Energy is planning to make annual payments to the Treasury for yet unrecovered prior Government investments in the uranium enrichment program. The total unrecovered investment is $7,500,000,000. The Administration is proposing a writedown of about $4,000,000,000 of this amount--the equivalent of writing off the plant capacity not in use. The remaining $3,500,000,000 will be paid with interest. In FY 1987, $235,000,000 in revenue collections will be returned to the Treasury consistent with the annual payment schedule for recovery of the prior Government investment.

Uranium Enrichment Revenues

In response to strong market pressure, including the offering by European competitors of prices 25 percent to 40 percent less than the United States prices, DOE has adapted a competitive pricing policy. In 1985, the price for commercial Utility Services contract holders was $135.00 per SWU. In FY 1986, a price reduction to $125.00 per SWU became effective. In FY 1987, we plan to reduce the price further to $119.00 per SWU. These prices are demonstrably consistent with the statutory requirement to recover the Government's costs over a reasonable period of time, in accordance with Section 161v of the Atomic Energy Act and with the Uranium Enrichment Services Criteria. In FY 1986 and FY 1987, sales are projected to remain low due to foreign competition and to customer workoff of inventories. Revenues in FY 1986 are estimated to be $1,360,600,000 from the sale of 9.3 million SWU to commercial customers and 1.7 million SWU to Defense Program customers. Revenues in FY 1987 are estimated to be $1,286,400,000 from the sale of 9.4 million SWU to commercial customers and 2.1 million SWU to Defense Program customers.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
NUCLEAR
Uranium Enrichment - Operating Expenses
Uranium Enrichment - Plant and Capital Equipment
(Tabular dollars in thousands. Narrative material in whole dollars)

Uranium Enrichment Activities (NE)	FY 1985 Appropriation	FY 1986 Appropriation[3]	FY 1987 Base	FY 1987 Request	Request vs Base
Gaseous Diffusion					
Operations and Support:					
Operating Expenses ...	$1,058,892[1]	$1,043,063	$1,043,063	$ 977,300	$ -65,763
Capital Equipment	11,000	13,472	13,472	1,000	-12,472
Construction	65,000	18,468	18,468	14,300	-4,168
Subtotal	1,134,892	1,075,003	1,075,003	992,600	-82,403
Atomic Vapor Laser Isotope Separation:					
Operating Expenses ...	74,800	109,660	109,660	50,000	-59,660
Capital Equipment	7,700	14,429	14,429	0	-14,429
Construction	500	2,886	2,886	0	-2,886
Subtotal	83,000	126,975	126,975	50,000	-76,975
Gas Centrifuge Program Closeout Activities:					
Gas Centrifuge Process Development and Demonstration:					
Operating Expenses .	76,000	17,315	17,315	4,000	-13,315
Capital Equipment ..	1,000	0	0	0	0
Construction	0	0	0	0	0
Subtotal	77,000	17,315	17,315	4,000	-13,315
Gas Centrifuge Enrichment Plant:					
Operating Expenses .	39,800	0	0	0	0
Capital Equipment ..	200	0	0	0	0
Construction	310,000	327,057	327,057	0	-327,057
Subtotal	350,000	327,057	327,057	0	-327,057
Subtotal, Gas Centrifuge Program Closeout Activities	427,000	344,372	344,372	4,000	-340,372
Program Direction:					
Operating Expenses ...	4,000[2]	4,036	4,036	4,800	+764
Total					
Operating	1,253,492	1,174,074	1,174,074	1,036,100	-137,974
Capital Equipment	19,900	27,901	27,901	1,000	-26,901
Construction	375,500	348,411	348,411	14,300	-334,111
Total, Uranium Enrichment Activities	$1,648,892	$1,550,386	$1,550,386	$1,051,400	$-498,986
Staffing TOTAL FTE's	69[2]	66[4]	66[4]	67	+1

Authorization: Sec. 16, P.L. 88-489

1/ Excludes $1,408,000 Appropriation transfer for S.B.I.R. in FY 1985.
2/ Does not reflect the comparability adjustment of 3 FTE transferred to the Department's ES&H organization.
3/ Adjustments to the FY 1986 Appropriation are shown on the table on the following page.
4/ Excludes 3 FTE Transferred to the Department's ES&H organization.

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Confer.	FTE General Reduction	Gramm-Rudman-Hollings	ES&H Transfer/ Reprogramming	Subtotal	Comparability Adjustments	Total
Uranium Enrichment Activities							
Gaseous Diffusion Operations and Support							
Operating Expenses	$1,084,600	$ -	$ -41,287	$ -250	$1,043,063	$ -	$1,043,063
Capital Equipment	14,500	-476	-552	-	13,472	-	13,472
Construction	19,200	-	-732	-	18,468	-	18,468
Subtotal	$1,118,300	$ -	$ -42,571	$ -	$1,075,003	$ -	$1,075,003
Enrichment Research and Development							
Gas Centrifuge Operations & Support							
Operating Expenses	18,000	-	-685	-	17,315	-17,315	-
Atomic Vapor Laser Isotope Separation							
Operating Expenses	114,000	-	-4,340	-	109,660	-109,660	-
Capital Equipment	15,000	-	-571	-	14,429	-14,429	-
Construction	3,000	-	-114	-	2,886	-2,886	-
Subtotal	$ 132,000	$ -	$ -5,025	$ -	$ 126,975	$-126,975	$ -
Subtotal Enrichment Research and Development	$ 150,000	$ -	$ -5,710	$ -	$ 144,290	$-144,290	$ -
Gas Centrifuge Enrichment Plant:							
Gas Centrifuge Operations & Support							
Construction	340,000	-	-12,943	-	327,057	-327,057	-
Atomic Vapor Laser Isotope Separation							
Operating Expenses	-	-	-	-	-	109,660	109,660
Capital Equipment	-	-	-	-	-	14,429	14,429
Construction	-	-	-	-	-	2,886	2,886
Subtotal	$ -	$ -	$ -	$ -	$ -	$ 126,975	$ 126,995
Gas Centrifuge Program Closeout Activities							
Gas Centrifuge Process Development and Demonstration							
Operating Expenses	-	-	-	-	-	17,315	17,315
Gas Centrifuge Enrichment Plant							
Construction	-	-	-	-	-	327,057	327,057
Subtotal, Closeout Activities	$ -	$ -	$ -	$ -	$ -	$ 344,372	$ 344,372
Program Direction:							
Operating Expenses	4,400	-	-167	-	4,233	-197	4,036
Total, Uranium Enrichment Activities	$1,612,700	$ -476	$ -61,391	$ -250	$1,550,583	$ -197	$1,550,386
Operating Expenses	1,221,000	-	-46,479	-250	1,174,271	-197	1,174,074
Capital Equipment	29,500	-476	-1,123	-	27,901	-	27,901
Construction	362,200	-	-13,789	-	348,411	-	348,411

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
SUMMARY OF CHANGES
URANIUM ENRICHMENT ACTIVITIES
(In thousands of dollars)

FY 1986 Appropriation enacted	$1,550,386
Built in increases and decreases:	
Pay cost supplemental	0
FY 1987 base	$1,550,386
Program increases and decreases:	
Gaseous Diffusion Operations and Support	
o Decrease due to lower power costs and savings from only operating the Paducah, Kentucky and Portsmouth, Ohio gaseous diffusion plants. The Oak Ridge gaseous diffusion plant will be maintained in a standby condition.	-82,403
Atomic Vapor Laser Isotope Separation	
o Decrease due to the use of existing facilities to resolve AVLIS technical issues and a new initiative to transfer the AVLIS technology to the private sector	-76,975
Gas Centrifuge Program Closeout Activities	
o Decrease due to gas centrifuge development and gas centrifuge enrichment plant programs being terminated	-340,372
Program Direction	
o Increase due to salaries, benefits, and travel for Uranium Enrichment staff, located at Headquarters and Oak Ridge offices.	+764
FY 1987 Budget Request	$1,051,400

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Gaseous diffusion operations and support ...	$1,134,892	$1,075,003	$ 992,600

The decrease of $82,403,000 from FY 1986 to FY 1987 is primarily due to lower power costs and savings from only operating the Paducah, Kentucky and Portsmouth, Ohio gaseous diffusion plants (GDPs). The Oak Ridge gaseous diffusion plant will be maintained in a standby condition.

Funding for this activity is required for the operation of the GDPs at Portsmouth, Ohio; and Paducah, Kentucky. Uranium enriched in the fissionable isotope U-235 is produced in these plants to meet utility customer and U.S. Government requirements for nuclear fuel. Funds are included for all of the operating and support requirements for the continued operation of the two diffusion plants and to assure that these plants are maintained in a reliable and safe manner. Funds are included for the purchase of cascade power, diffusion operations, process and long-range technical support, supporting services, change in inventories, and cost of Uranium Enrichment Services Activity (UESA) requirements. In addition, funds are included for necessary capital equipment to support the operational requirements of the plants. The GDP located at Oak Ridge, Tennessee, will continue to be maintained in a standby condition. The Oak Ridge GDP will be maintained in a standby condition with Defense Programs providing the standby funding because of projected Defense demand for enrichment services in the outyears. If the standby funding is not provided, the Oak Ridge GDP will be permanently shut down. If the plant is permanently shut down, it will not be operable because critical components will not be maintained.

The FY 1987 production target of about 7.6 million SWU and the associated power costs were selected following an analysis to minimize the enrichment enterprise costs. In addition, the nonpower operating costs have been reduced to minimize the funding needed to reliably and safely operate and maintain the plants.

This decision unit reflects $-5,000,000 for savings resulting from management initiatives in the area of administrative processes/field structure. Some of these savings will occur in gas centrifuge program closeout activities.

Funds are also requested for capital equipment and for the following new line item construction projects: (1) cooling tower upgrading and (2) General Plant Projects (GPP).

Gaseous diffusion operations and support - operating expenses			
Cascade power	$ 870,300	$ 842,713	$ 829,600
Diffusion operations	151,000	157,450	116,700
Process and long-range technical support	16,200	15,200	10,000
Supporting services	16,392	20,600	21,300
Change in inventories	500	1,500	-5,300
Cost of UESA services	4,500	5,600	5,000
Subtotal, operating expenses	1,058,892	1,043,063	977,300
Cascade power	$ 870,300[1/]	$ 842,713[2/]	$ 829,600[3/]

Operation of the GDP's requires large amounts of electric power to pump the process gas uranium hexafluoride (UF_6) through the separating stages. Electric power is obtained

1/ Includes approximately $347,000,000 for capacity charges for power not purchased under the contracts in effect in FY 1985 with the Tennessee Valley Authority.

2/ Includes approximately $432,000,000 for capacity charges for power not purchased under the contracts expected to be in effect in FY 1986 with the Tennessee Valley Authority.

3/ Includes approximately $454,000,000 for capacity charges for power not purchased under the contracts expected to be in effect in FY 1987 with DOE's three power suppliers.

under long-term contracts from the following suppliers: Tennessee Valley Authority (TVA)--Oak Ridge (in standby) and Paducah; Electric Energy Incorporated (EEInc.)--Paducah; and Ohio Valley Electric Corporation (OVEC)--Portsmouth.

Power from EEInc. and OVEC is obtained from generating stations with a portion or all of the capacities of these stations serving DOE. DOE pays a proportionate share of the total costs incurred by the suppliers for the power it purchases. Power from TVA is purchased from the TVA system at rates patterned after TVA standard industrial rates. TVA can adjust its rates on a quarterly basis to assure meeting bonding and TVA legislative requirements to provide an adequate margin of revenues over costs.

The total power purchased includes cascade power, power used by the Oak Ridge National Laboratory, the Y-12 complex at Oak Ridge, nonprocess users at all gaseous diffusion sites, and line losses. Cascade power is the portion of purchased power that is used to operate the gaseous diffusion process equipment and auxiliaries.

In the short term, the low operating levels of the gaseous diffusion complex require power purchases below existing contract levels. Therefore, the Department must pay capacity charges to its power suppliers for power not purchased to the extent that efforts to negotiate reduced power levels are unsuccessful. DOE has been, and will continue, negotiating with the suppliers in an attempt to reduce or eliminate these capacity charges. To date, these negotiations with the TVA have been unsuccessful and the Department has paid approximately $0.8 billion for power not purchased.

In FY 1987 the enrichment complex will operate at about 2,095 megawatts which is the same as the FY 1986 power level. If FY 1986 or FY 1987 revenue collections drop below current projections, it may be necessary to reduce power purchases in order to maintain the planned payments to Treasury. The contract power that DOE will not be purchasing from the suppliers increases from 4,385 megawatts in FY 1986 to 4,465 megawatts in FY 1987. The budget request for FY 1987 is estimated at $829,600,000. The estimate of capacity charges for power not purchased, which will be paid to TVA ($451,000,000), EEInc. ($1,000,000), and OVEC ($2,000,000), is $454,000,000 or 55 percent of the total power budget request and 43 percent of the total budget request for programmatic activities. Within the requested funding, nonpeak/unfirm power may be purchased subject to the availability of the power and the economics of the separative work produced.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Diffusion operations	$ 151,000	$ 157,450	$ 116,700

This activity includes all funds needed to operate the GDPs except funds needed for electric power; including wages, employee benefits, supplies and expenses associated with plant operations; the cost of maintenance of equipment, buildings, and facilities used in the production of enriched UF_6; the costs to perform technical and production services such as plant engineering, laboratory studies, decontamination, handling of source and special materials and uranium control; utility services, including water, nitrogen, steam, and dry air; and a pro rata share of essential plant services such as security, health and safety, as well as janitorial, grounds maintenance, safety analysis, environmental and site development studies, and general and administrative expenses.

The decreased funding request in FY 1987 reflects maintaining the Oak Ridge GDP in a standby condition. (Standby costs are included in the supporting services activity.) The funding request in FY 1987 also includes efforts to consolidate and streamline functions, including manpower reductions where required, in order to enhance the overall efficiency of the operation.

Process and long-range technical support ...	$ 16,200	$ 15,200	$ 10,000

The process and long-range technical support activities help to assure the minimum cost operation of the GDP's at the required production levels. The primary activity in FY 1987 will be technical efforts directed toward sustaining plant productivity by

minimizing operating problems, adapting to changing conditions and optimizing operations under these changing conditions. A specific example of past success in this area is the development and implementation of compressor modifications which allow more efficient operation at low power levels. In addition, the existing plants will be required to comply with all current and future environmental, health, safety, and other policy or regulation changes. The effective treatment of such problems will be a significant part of the technical support effort.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Supporting services	$ 16,392[1/]	$ 20,600	$ 21,300

The supporting services activity is needed to assure the smooth and efficient operation of the GDPs. The requested funds will be used to maintain gaseous diffusion stages and associated facilities in standby at Portsmouth and Paducah; maintain feed facilities in standby; maintain the Oak Ridge plant in a standby condition; fund inter-plant product flow and other shipments among the gaseous diffusion sites, including the guarding in transit of classified material; fund warehousing of uranium in various forms at the gaseous diffusion sites; fund special management studies, including conceptual design work for needed line-item construction and GPP's planned for future years; funds for engineering and planning studies to support needed capital improvements and to improve operating efficiency; funds for marketing activities, and funds for various production optimization and demand studies, and special study requests. Also included are funds for recovery of diffusion scrap and for the Grand Junction uranium leasing program.

Change in inventories	$ 500	$ 1,500	$ -5,300

The request for Changes in Common-Use Stores and Special Process Spares inventories reflects an effort to reduce the size of the Oak Ridge GDP inventory in light of it being in a standby condition.

Cost of UESA services	$ 4,500	$ 5,600	$ 5,000

These costs are incurred at the Portsmouth plant for withdrawal and analysis of product shipped under commercial toll enriching service contracts, and product shipped to other Federal agencies. Oak Ridge toll facilities may be required for some activities. These costs are matched by miscellaneous revenues received from the customers for these services.

Gaseous diffusion operations and support - capital equipment	$ 11,000	$ 13,472	$ 1,000

These funds are primarily needed to replace equipment at field sites that have exceeded their useful life and to purchase additional equipment needed to meet program objectives in a more effective and efficient manner. Some funds may be needed to purchase headquarters automatic data processing equipment. The decreased funding is primarily related to the Oak Ridge GDP being in a standby condition.

Gaseous diffusion operations and support - construction	$ 65,000	$ 18,468	$ 14,300
Project 87-N-501, General plant projects, various locations (TEC $1,200)	0	0	1,200

This project provides for various items of new construction, additions, alterations, and retirements to the land, buildings, and utility systems at the three GDPs. The GPPs

1/ Excludes $1,408,000 transferred for S.B.I.R.

are necessary to meet continuing requirements to maintain the facilities in a good state of repair, to adapt the facilities to new or improved production techniques, to effect economics of operation, and to reduce or eliminate health, safety, environment, and security problems.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Project 87-N-502, Cooling tower upgrading, Paducah, Kentucky (TEC $6,300)	$ 0	$ 0	$ 6,300

This project provides for upgrading three cooling towers at the Paducah, Kentucky, GDP. The cooling tower fill, drift eliminators, and selected structural members will be replaced. The components have deteriorated due to time and use and must be replaced to be able to perform their required function of cooling the process equipment.

Project 84-N-405, Utilities upgrading, Phase III, Paducah, Kentucky; and Portsmouth, Ohio (TEC $26,916)	$ 12,000	$ 2,116	$ 6,800

This project will upgrade certain utility and auxiliary systems at the GDPs as defined by recent reliability studies. These upgrades will provide the operational reliability required for these vital support systems to sustain normal, safe, and efficient cascade operations. The upgrading includes structure and system work on cooling towers at aducah, Kentucky; and electrical systems at Paducah; Kentucky; and Portsmouth, Ohio.

Prior year projects	$ 53,000	$ 16,352	$ 0
Atomic vapor laser isotope separation	$ 83,000	$ 126,975	$ 50,000

The decrease of $76,975,000 from FY 1986 to FY 1987 reflects the Department's new initiative to transfer the Atomic Vapor Laser Isotope Separation (AVLIS) technology to the private sector and obtain private sector financial involvement in deployment of AVLIS. Specifically, the involvement of Martin Marietta Energy Systems in the program will be significantly reduced. All near-term activities will be focused on the use of the existing facilities and the resolution of outstanding technical problems.

The long-term goal of the AVLIS program is to develop a technology that will assure the United States enrichment enterprise long-term price competitiveness by producing enriched uranium at a cost significantly less than the marginal production costs for GDPs. The near term policy goal of the AVLIS program is to transfer development and ultimate deployment of the technology to the private sector. The details for determining private sector interest are currently under development.

The near-term technical goal is to focus the experimental program on investigation of those issues documented by the Process Evaluation Board (PEB) in FY 1985 as being technically critical or having high economic leverage. This work will be carried out in existing facilities. Integrated enrichment experiments will be conducted at approximately one-half plant scale at low laser power. This scale will increase confidence in current technical and economic extrapolations prior to proceeding with full-scale demonstration of the process. During FY 1987, the Department will emphasize those research and development activities that add credibility to the performance and cost projections of the technology so that the viability of AVLIS for private sector investment is established. A primary focus will be on separator subsystems where plant prototypical testing will be initiated to understand uranium vapor properties, transport and efficiency. Planned activities in the laser area are to continue component development on higher powered

laser systems and increased optical efficiency. The purpose is to increase process performance and reliability, thereby reducing cost.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Atomic vapor laser isotope separation - operating expenses			
Laser demonstration	$ 26,200	$ 26,200	$ 6,300
Uranium separation/processing demonstration	32,400	60,860	28,400
Integration and support	15,200	16,800	9,300
Technology transfer and analysis	1,000	5,800	6,000
Subtotal, operating expenses	$ 74,800	$ 109,660	$ 50,000
Laser demonstration	$ 26,200	$ 26,200	$ 6,300

This category includes such activities as design, test, and evaluation of laser components and hardware that will be used in the Laser Demonstration Facility (LDF). The effort is directed toward improving laser system performance and efficiency and lowering costs for equipment and operations. This category also includes the design, construction, fabrication, and operation of the LDF. During FY 1986, the emphasis will be on achievement of routine operation of the LDF. In FY 1987, emphasis will be placed on demonstrating performance.

Laser Demonstration and Test

The primary laser demonstration and test emphasis in FY 1986 will be to address key technical issues including efforts required to increase the performance and reliability of the LDF to levels necessary for sustained 24-hour/day operations. Copper laser technology efforts include high average power laser development, pulse power technology development, power supply engineering, copper containment, plasma tube/insulation materials and manufacturing methods development, and evaluation of reliability-improvement and cost reductions methods.

During FY 1987, efforts will support the next design iteration of the LDF laser system. Higher power laser systems and improved optical efficiency will also be under development.

The objectives of the program in support of this phase will be to design demonstration equipment that has improved efficiency, reliability, quality, lower costs, and is transferrable to the private sector. These improvements will be made based on the procurement, quality assurance, and operating experiences with current equipment.

Laser Demonstration Facility

In FY 1985, the initial phase, first-of-a-kind laser system was installed and operated to support the FY 1985 process selection. Several areas are being addressed to resolve quality control and engineering problems observed during operation and to complete activation work that was precluded by the compressed demonstration schedule. These areas include copper laser reliability and lifetime, dye laser performance optimization and beam propagation, optical system component sizing and high average power effects, activation of pointing and centering systems and diagnostic packages, and supervisory control system interfaces and access time. This activity will be completed in FY 1986.

The program emphasis in FY 1987 will include continuous operation of the LDF. Continuous 24-hour/day, 7-day/week operation of the LDF lasers results in improved system performance and reliability. The laser operation will emphasize the use of management control systems and operational methods typical of the industrial environment in preparation for increased industrial participation.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Uranium separation/processing demonstration	$ 32,400	$ 60,860	$ 28,400

This area of program activity is concerned with all facets of uranium separation and processing in the AVLIS process. This includes: the design, development, and test of components and systems used to separate uranium-235 atoms in a uranium vapor; design, construction, and operation of separator test facilities to test separator components and systems at both sub-scale and full scale; conduct of integrated enrichment tests using laser light supplied from the LDF, currently using the one-half scale MARS separator facility with low laser power but ultimately at full scale with full power; and design, development, and test of processing systems to provide uranium feed to the separator and removal of product and tails.

There are three major separator test facilities in use: 1) the one-half scale MARS facility located at Lawrence Livermore National Laboratory (LLNL), 2) the Separator Demonstration Facility (SDF) at LLNL, designed for full-scale testing when completely outfitted in future years but capable of component testing only at this time, and 3) the Materials Handling Demonstration Module (MHDM) operated by Martin Marietta Energy Systems (MMES) at Oak Ridge, Tennessee.

The primary objectives in this area in FY 1987 include the completion of the one-half scale, low power integrated enrichment test series, and completion of activation and testing of the first generation uranium vaporizer in the SDF.

Separator Demonstration and Test

In FY 1986, efforts will focus on one-half scale integrated enrichment experiments and component development for full-scale systems to address key technical issues. Subscale system tests will concentrate on understanding and improving the performance of the baseline collector design. Methods for thermal control will be tested and a more detailed understanding of factors that degrade product enrichment will be developed.

In FY 1987, the one-half scale integrated enrichment experiments will be completed for the baseline collector and emphasis will be placed on documentation for technology transfer. Engineering design and design verification tests will be conducted for the first full scale separator pod (a pod is the smallest group of components in which uranium separation occurs).

Operation and testing in SDF in FY 1986 will concentrate on activation of the vaporizer and vaporizer subsystems. Comparison between analytical calculations and experimental data will be used to improve process performance models, establish subsequent hardware design changes, and document the experimental data base for the private sector. In FY 1987, extensive testing of the vaporizer will be completed. Information obtained from this phase of operation will include optimum vaporizer operating conditions, throughput efficiency and initial vapor properties. These later results will be documented and transferred to industry.

Operations in MHDM will be halted in FY 1986 and remaining FY 1986 funds will be used for decommissioning and decontamination. Further participation by MMES in the program will be significantly reduced in FY 1987.

Separator Demonstration Facility

Further activities to complete assembly and installation of equipment in the SDF will be limited in FY 1987. Emphasis will be placed on providing facilities necessary to address major technical uncertainties and to complete testing of the vaporizer and vaporizer subsystems. Work to complete assembly and installation of the first full

scale separator pod and associated support systems will be deferred pending results of the private sector solicitation.

Uranium Processing Demonstration

In FY 1986, an effort will begin to evaluate alternatives, conduct tests, and design studies leading to the selection of the appropriate method to provide uranium feed material to an AVLIS plant. All activities in this category will be suspended in FY 1987.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Integration and support	$ 15,200	$ 16,800	$ 9,300

This category includes all technical integrating functions necessary to support laser and separator development, as well as project management and other general support activities.

Technical Integration

Primary activities include long range process development, process integration, production plant designs, and deployment studies. In process integration, a major FY 1987 activity will be the support, analysis, and documentation of the integrated enrichment test series using the LDF lasers and the MARS separator. In FY 1986, production plant design activity will be maintained at a low level to provide assessments of the impacts of variation in production plant designs, improvements, or deployment options. In FY 1987, plant design will be limited to maintaining the point design as the reference for other development activities. All other design activities will be deferred pending determination of further private sector interest in proceeding with a production plant.

Management and Support

This activity includes all project management and general support functions such as security, utilities, etc.; project planning and control; and conventional facilities such as warehouses, shop facilities, and outside utilities.

Technology transfer and analysis	$ 1,000	$ 5,800	$ 6,000

Consistent with the program goal to transfer AVLIS to the private sector, emphasis will be placed on conducting activities to facilitate this transfer. Documentation of the existing technology will be prepared. Detailed data packages will be prepared and technology transfer seminars will be conducted to facilitate private sector evaluation of AVLIS. Supporting services, such as technical and economic analysis, will be performed to support private parties in preparing their expressions of interest.

In addition, independent assessment and analysis of AVLIS technology will be continued at a reduced level. This effort will concentrate on the readiness of the technology to be transferred to private industry and to assist the private sector in their analyses of the AVLIS technology.

Atomic vapor laser isotope separation - capital equipment	$ 7,700	$ 14,429	$ 0

No additional capital equipment funds are requested.

Atomic vapor laser isotope separation - construction	$ 500	$ 2,886	$ 0

No additional General Plant Projects (GPP) funds are requested.

Prior Year Projects	$ 500	$ 2,886	$ 0

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Gas centrifuge program closeout activities .	$ 427,000	$ 344,372	$ 4,000

The decrease of $340,372,000 is due to gas centrifuge development and gas centrifuge enrichment plant programs being terminated.

Funding for this activity is requested to continue closeout and termination activities associated with the gas centrifuge process development and demonstration program and gas centrifuge enrichment plant program.

Gas centrifuge process development and demonstration	$ 77,000	$ 17,315	$ 4,000

Funding for this activity is requested to continue closeout and termination of the gas centrifuge development program.

Gas centrifuge process development and demonstration - operating expenses	$ 76,000	$ 17,315	$ 4,000

Funding for this activity is requested to complete termination of activities associated with the gas centrifuge development program. Historical and technical documentation will be completed; decommissioning and decontamination of contractor-owned facilities, which was begun in FY 1986, will be concluded and the facilities restored to original condition; and sale or transfer of test and other equipment will probably be complete. Selected centrifuge facilities at the Oak Ridge K-25 facility, including the Centrifuge Plant Demonstration Facility, may be maintained in a standby mode to be available for specialty isotope enrichment efforts if those efforts can be identified. By the end of FY 1987, termination or reassignment of contractor employees will probably be completed, final audits and validation of provisional payments from prior years are planned to be accomplished, and final settlements made on all contracts to the best of our ability. A small number of termination activities may not be completed until FY 1988.

Gas centrifuge process development and demonstration - capital equipment	$ 1,000	$ 0	$ 0
Gas centrifuge process development and demonstration - construction	$ 0	$ 0	$ 0
Gas centrifuge enrichment plant	$ 350,000	$ 327,057	$ 0

Funding for this activity is requested to continue termination of the gas centrifuge enrichment plant program. No additional budget authority is required for this activity; however, costs and outlays will continue to be incurred for termination activities. A small number of termination activities may not be completed until FY 1988.

Gas centrifuge enrichment plant - operating expenses

Gas centrifuge operations	$ 1,900	$ 0	$ 0
Supporting services	37,900	0	0
Subtotal, operating expenses	$ 39,800	$ 0	$ 0
Gas centrifuge operations	$ 1,900	$ 0	$ 0

No additional budget authority is required for this activity; however, costs and outlays will continue to be incurred for termination activities.

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Supporting Services	$ 37,900	$ 0	$ 0

No additional budget authority is required for this activity; however, costs and outlays will continue to be incurred for termination activities.

Gas centrifuge enrichment plant - capital equipment	$ 200	$ 0	$ 0

No additional budget authority is required for this activity; however, costs and outlays will continue to be incurred for termination activities.

Gas centrifuge enrichment plant - construction	$ 310,000	$ 327,057	$ 0
Project 76-8-g, Enriched uranium production facilities, Portsmouth, Ohio	310,000	327,057	0

No additional funding is requested for this project. Termination was announced by the Secretary of Energy on June 5, 1985. Contracts for equipment, construction, engineering, technical support, and manufacture of centrifuges are expected to be closed out during the FY 1987 budget year. A small number of termination activities may not be completed until FY 1988. The GCEP facility will be retired or transferred to others for alternate use(s) if possible. Contractor employees will be terminated as the above contractors are phased out. To the best of our ability final audits, validation of provisional payments, and final payments on contracts will be made in FY 1987.

Program Direction	$ 4,000	$ 4,036	$ 4,800

The increase of $764,000 from FY 1986 to FY 1987 is required for the Headquarters and field personnel associated with the uranium enrichment program. Funds are included to continue management support in the Office of Uranium Enrichment, and for certain enrichment related work at the Oak Ridge Operations Office. This funding request provides for personal services, personnel benefits, travel, and contractual services and supplies, as follows:

Program Direction
(Tabular Dollars in Thousands)

	FY 1985		FY 1986		FY 1987	
	B/A	Obs	B/A	Obs	B/A	Obs
Personnel Compensation:						
Full-Time Permanent	$	$2,926	$	$3,314	$	$3,218
Other than Full-Time		6		0		0
Other Personnel Compensation		129		10		174
Total Personnel Compensation		3,061		3,324		3,392
Personnel Benefits: Civilian		319		372		381
Benefits for Former Personnel		44		0		0
Travel and Transportation of Persons ...		552		705		710
Other Services (Contractual Services) ..		317		399		317
Total	$4,000	$4,293	$4,036	$4,800	$4,800	$4,800

This decision unit reflects $-49,000 for savings resulting from GS-11 to GS-15 bulge reductions.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
NUCLEAR
Uranium Enrichment - Operating Expenses
Uranium Enrichment - Plant and Capital Equipment
(Tabular dollars in thousands. Narrative material in whole dollars)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Payment to Treasury (NE)					
Operating Expenses ..	$	$	$	$	$
Capital Equipment ...					
Construction					
Total	$ 0	$ 0[1/]	$ 0[1/]	$ 235,000	$+235,000

Authorization: Sec. 16, P.L. 88-489

SUMMARY OF CHANGES

FY 1986 Appropriation enacted	$ 0[1/]
Program increases and decreases:	
o FY 1987 payment	+235,000
FY 1987 Budget Request	$ 235,000

PROGRAM BUDGET JUSTIFICATION

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Payment to Treasury	$ 0	$ 0[1/]	$ 235,000

The Department of Energy is planning to make annual payments to the Treasury for prior Government investments in the uranium enrichment program. As of the end of FY 1985, the total unrecovered investment is about $7,500,000,000. The Administration is proposing to write down this level of debt to $3,500,000,000. The $4,000,000,000 reduction is the equivalent of eliminating the recovery of unused plant capacity. Interest will be charged each year on the average balance of the reduced Government investment at the rate of 6.3 percent. The rate is weighted average of Treasury borrowing rates existing in the years in which there was a net increase in unrecovered Government investment.

In FY 1987, $235,000,000 in revenue collections will be returned to the Treasury in accordance with the annual payment schedule for recovering prior Government investment.

1/ Revenues in excess of outlays of approximately $110,000,000 will accrue to the Treasury in FY 1986.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
NUCLEAR
Uranium Enrichment - Operating Expenses
Uranium Enrichment - Plant and Capital Equipment
(Tabular dollars in thousands. Narrative material in whole dollars)

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Uranium Enrichment Revenues (NE)					
Operating Expenses .	$	$	$	$	$
Capital Equipment ..					
Construction					
Total	$-1,410,936[1/]	$-1,360,600	$-1,360,600	$-1,286,400	$ +74,200

Authorization: Sec. 16, P.L. 88-489

SUMMARY OF CHANGES

FY 1986 Appropriation enacted[2/]	$-1,360,600
Program increases and decreases:	
o Decrease in commercial revenues	+113,100
o Increase in Government revenues	-38,900
FY 1987 Budget Request	$-1,286,400

1/ Actual collections.
2/ While the Uranium Supply and Enrichment Activities Appropriation bill estimated revenue collections of $1,612,700,000, the current estimate of revenues that are expected to be collected is $1,360,600,000.

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

Uranium Enrichment Revenues	FY 1986 Confer.	FTE General Reduction	Gramm-Rudman-Hollings	ES&H Transfer/ Reprogramming	Subtotal	Comparability Adjustments	Total
Total Revenues	$-1,375,000	-	-	-	$-1,375,000	-	$-1,375,000
Less Impact of GRH on Government Sales	14,400	-	-	-	14,400	-	14,400
Adjusted Revenues	$-1,360,600	-	-	-	$-1,360,600	-	$-1,360,600

	FY 1985 Appropriation	FY 1986 Appropriation	FY 1987 Request
Uranium enrichment revenues	$-1,410,936	$-1,360,600	$-1,286,400

The estimate for uranium enrichment revenues includes the sale of uranium enrichment services for use in nuclear power reactors for foreign and domestic customers. Also included in this activity are the sale of enrichment services to Defense Programs, advance payments received from customers, and miscellaneous revenues related to uranium enrichment activities as detailed below.

Sale of uranium enrichment services to commercial customers	$-1,325,136	$-1,221,000	$-1,112,900
Sale of uranium enrichment services to Defense Program customers	-142,800	-169,600	-208,500
Subtotal, sale of uranium enrichment services	-1,467,936	-1,390,600	-1,321,400
Advanced payments on long-term fixed commitment contracts	+67,000	+37,000	+42,000
Subtotal, toll enriching revenues	-1,400,936	-1,353,600	-1,279,400
Miscellaneous revenues	-10,000	-7,000	-7,000
Total, uranium enrichment revenues	$-1,410,936	$-1,360,600	$-1,286,400
Sale of uranium enrichment services	$-1,467,936	$-1,390,600	$-1,321,400

The FY 1987 estimate is based on the sale of 9.4 million commercial SWU sales. In each instance, the toll enrichment customer supplies feed to the Department in the form of UF_6 of normal assay and the agency processes the UF_6 in the GDPs to the level of enrichment in the U-235 isotope specified by the customer. This revenue estimate is based on a price of $119.00 per SWU to commercial customers. Additionally, 2.1 million SWUs are sold to Defense Program customers at a value of $208,500,000, which is being provided by the Atomic Energy Defense Activities appropriation in DOE. Included in the sale of uranium enrichment services are revenues from the termination charges associated with the cancellation of commercial SWU purchases.

Advanced payments on long-term fixed commitment contracts	$ +67,000	$ +37,000	$ +42,000

The long-term fixed commitment contracts contained provisions for advance customer payments to the Department. These advance payments are credited against future deliveries of toll enriching services. The estimate for FY 1987 reflects the applicable credits against FY 1987 sales of toll enriching services for advance payments made in prior years.

Miscellaneous revenues	$ -10,000	$ -7,000	$ -7,000

Miscellaneous revenues consist of packaging and handling charges, late payment charges, sales from deferred sales contracts, and related items.

This decision unit reflects a $-25,000,000 increase in revenue collections due to improved debt collection operations.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
URANIUM ENRICHMENT - PLANT AND CAPITAL EQUIPMENT
URANIUM ENRICHMENT
URANIUM ENRICHMENT ACTIVITIES
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: General plant projects, various locations

2. Project No. 87-N-501

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 1st Qtr. FY 1987

4. Date construction ends: 4th Qtr. FY 1989

5. Previous cost estimate:
Date: $ None

6. Current cost estimate:
Date: 1/86 $ 1,200

7. Financial Schedule:

		Costs			
Fiscal Year	Obligations	FY 1985	FY 1986	FY 1987	After FY 1987
Prior year projects	$ XXXX	$15,443	$12,790	$ 5,600	$23,967
FY 1987	1,200[1/]	0	0	200	1,000

8. Brief Physical Description of Project:

Expenditures for general plant projects to replace, upgrade, and maintain facilities will continue in FY 1987. The age and condition of the plant and continuing concern for the protection of employees, the public, and the environment will affect the levels of general plant projects required. By nature, general plant projects are such that they are not always identifiable on a prospective basis; and even where they are identifiable, there is a brand of uncertainty about physical and financial scope. This project or some of these projects may be located on non-Government owned land. The following pages describe specific projects as representative of the types of work that current needs dictate or that have been shown by experience to be the kinds of miscellaneous construction required to support normal operations.

1/ This project also requires FY 1987 Authorizations and Appropriations of $1,200,000.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations

2. Project No. 87-N-501

8. Brief Physical Description of Project: (Continued)

This project provides for general plant project capital alterations and additions, such as building and utility systems required for production programs at Paducah, Kentucky; Portsmouth, Ohio; and Oak Ridge, Tennessee. It includes the cost of installed equipment where such is an integral part of general plant projects.

The estimate provides for all general plant projects required for the following:

a. The uranium enrichment plants and supporting facilities at Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio.

b. The Oak Ridge, Tennessee administrative projects, including the Federal Building, security facilities, and other direct requirements.

9. Purpose, Justification of Need for, and Scope of Project:

General plant projects are necessary and continuing requirements to maintain the facilities in a satisfactory state of repair, to adapt the facilities to new or improved production techniques, to effect economics of operations, and to reduce or eliminate health, fire, and security problems. Process development and changes in technical program requirements frequently result in the need for alterations or new construction items not previously anticipated. The total project estimate is made up of the anticipated level of work required by each participant. This level takes into account past experience, planned program changes and technological advances.

Estimates by location are as follows:

Oak Ridge Gaseous Diffusion Plant	$ 100
Paducah Gaseous Diffusion Plant	500
Portsmouth Gaseous Diffusion Plant	500
All Other Oak Ridge Operations	100
Total Uranium Enrichment Activities	$ 1,200

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations

2. Project No. 87-N-501

9. Purpose, Justification of Need for, and Scope of Project: (Continued)

Following are examples of general plant projects identified at this date which may be required in FY 1987.

Oak Ridge Gaseous Diffusion Plant..... $ 100,000

Funding is requested for utility, security, environmental or other requirements to place and maintain the Oak Ridge gaseous diffusion plant in a standby condition.

Paducah Gaseous Diffusion Plant..... $ 500,000

Emergency Generator..... $ 200,000

Installation of a 250 KW emergency generator is planned at the water treatment plant to provide emergency power for equipment that operates on 440 volts or less. The existing 150 KW emergency generator is marginal for requirements posed by equipment additions that have been made in recent years at the water treatment facility. The new generator will be installed in a location which is not subject to flooding as is the present generator location.

Technical Services Building..... $ 300,000

Renovation is planned to replace components of mechanical systems that have had extended service life and which need to be maintained to prepare the building for long-term operations.

Portsmouth Gaseous Diffusion Plant..... $ 500,000

Steam Plant..... $ 500,000

Retubing of one 125,000 lb./hour steam boiler is required due to the deteriorated state of existing original tubes. Significant maintenance expense is required annually to permit continued use of the existing tubes, and any further delay in total retubing will jeopardize the supply of steam required for plant operation.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: General plant projects, various locations

2. Project No. 87-N-501

9. Purpose, Justification of Need for, and Scope of Project: (Continued)

All Other, Oak Ridge Operations..... $ 100,000

Miscellaneous other projects are mainly for improvements to the Security Department, Patrol Range, Motor Pool, Security Operations Center, and the Computer Facility.

10. Details of Cost Estimate:

Cost estimate details have not been developed. Such detailed estimates are made in connection with each individual project request after specific need and scope have been established and after completion of preliminary engineering.

11. Method of Performance:

Design and inspection will be performed by the operating contractor. To the extent feasible, construction and procurement will be accomplished by fixed-price contracts awarded to the lowest bidder.

12. Funding Schedule of Project Funding and Other Related Funding Requirements:

No narrative required.

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements:

No narrative required.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
URANIUM ENRICHMENT - PLANT AND CAPITAL EQUIPMENT
URANIUM ENRICHMENT
URANIUM ENRICHMENT ACTIVITIES
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Cooling tower upgrading
Paducah, Kentucky, Gaseous Diffusion Plant

2. Project No. 87-N-502

3. Date A-E work initiated: 1st Qtr. FY 1987

3a. Date physical construction starts: 1st Qtr. FY 1988

4. Date construction ends: 4th Qtr. FY 1990

5. Previous cost estimate:
Date: $ None

6. Current cost estimate:
Date: 1/86 $ 6,300

7. Financial Schedule:

Fiscal Year	Authorizations	Appropriations	Obligations	Costs
1987	$ 6,300	$ 6,300	$ 6,300	$ 200
1988	0	0	0	1,600
1989	0	0	0	3,500
1990	0	0	0	1,000

8. Brief Physical Description of Project:

This project provides for upgrading three of the cooling towers at the Paducah, Kentucky, Gaseous Diffusion Plant. The cooling towers, which remove process heat from the diffusion cascade, will be upgraded by replacement of fill, drift eliminators, and selected structural members.

9. Purpose, Justification of Need for, and Scope of Project:

The cooling towers proposed to be upgraded in this project are necessary support systems to assure continued operation of the diffusion cascade. A reliability study and an inspection report substantiate the need for cooling tower fill replacement and structural upgrading in this timeframe. These components have deteriorated due to time and use and must be replaced in order to be able to perform their required function of cooling the process equipment.

1. Title and location of project: Cooling tower upgrading
Paducah, Kentucky, Gaseous Diffusion Plant

2. Project No. 87-N-502

9. Purpose, Justification of Need for, and Scope of Project: (Continued)

Delay in implementation of this project will increase the risk to plant operations from continued deterioration of these systems.

No increase in operating costs will result from implementation of this project. Operating costs of these systems should reduce due to the lower costs to maintain the cooling towers.

10. Details of Cost Estimate:*

	Paducah
a. Engineering, design and inspection at approximately 17% of construction costs, Item b.	$ 770
b. Construction costs	
(1) Improvements to land	0
(2) Building	0
(3) Other structures	4,495
(4) Special facilities	0
Subtotal	5,265
c. Contingency at approximately 20% of above costs	1,035
Total project costs	$ 6,300

11. Method of Performance:

Title I and II design will be performed under a negotiated Architect-Engineer contract. To the extent feasible, construction and procurement will be accomplished by fixed-price subcontract(s) awarded on the basis of competitive bidding. A-E support activities, Title III inspections, and subcontract administration will be performed by the operating contractor.

*Based on conceptual design completed March 1985.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Cooling tower upgrading
Paducah, Kentucky, Gaseous Diffusion Plant

2. Project No. 87-N-502

12. Funding Schedule of Project Funding and Other Related Funding Requirements:

	Prior Years	FY 1987	FY 1988	FY 1989	FY 1990	Total
a. Total project costs						
1. Total facility costs						
(a) Construction line item.....	$ 0	$ 200	$ 1,600	$ 3,500	$ 1,000	$ 6,300
(b) PE&D	0	0	0	0	0	0
(c) Expense funded equipment	0	0	0	0	0	0
(d) Inventories	0	0	0	0	0	0
Total facility costs	0	200	1,600	3,500	1,000	6,300
2. Other project costs						
(a) R&D necessary to complete construction	0	0	0	0	0	0
(b) Conceptual design costs.....	93	0	0	0	0	93
(c) Other project related costs .	0	0	0	0	0	0
Total other project costs ...	93	0	0	0	0	93
Total project costs	$ 93	$ 200	$ 1,600	$ 3,500	$ 1,000	$ 6,393

b. Other related annual costs	
1. Facility operating costs	$ 0
2. Programmatic operating expense directly related to the facility	0
3. Capital equipment not related to construction but related to the programmatic effort in the facility	0
4. GPP or other construction not related to programmatic effort in the facility	0
5. Other costs	0
Total other related annual costs	$ 0

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements:

a. Total project costs
1. Total facility costs. No narrative required.
2. Other project costs. No narrative required.

b. Other related annual costs
1. Facility operating costs are expected to be reduced due to improved operational efficiency and reduced maintenance costs. No additional operating personnel will be required.
2 thru 5. No narrative required.

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
CONSTRUCTION PROJECT DATA SHEETS
URANIUM ENRICHMENT - PLANT AND CAPITAL EQUIPMENT
URANIUM ENRICHMENT
URANIUM ENRICHMENT ACTIVITIES
(Tabular dollars in thousands. Narrative material in whole dollars.)

1. Title and location of project: Utilities upgrading, Phase III, Paducah, Kentucky and Portsmouth, Ohio

2. Project No. 84-N-405

3. Date A-E work initiated: 1st Qtr. FY 1984

3a. Date physical construction starts: 3rd Qtr. FY 1984

4. Date construction ends: 1st Qtr. FY 1991

5. Previous cost estimate:
Date: 12/84 $ 27,000

6. Current cost estimate:
Date: 1/86 $ 26,916

7. Financial Schedule:

Fiscal Year	Authorizations	Appropriations	Obligations	Costs
1984	$ 6,000	$ 6,000	$ 5,000	$ 676
1985	12,000	12,000	13,000	3,832
1986	2,116 1/	2,116 1/	2,116 1/	1,740
1987	6,800	6,800	6,800	1,200
1988	0	0	0	2,700
1989	0	0	0	7,000
1990	0	0	0	5,600
1991	0	0	0	4,168

8. Brief Physical Description of Project:

This project provides for upgrading selected utility and auxiliary systems at the gaseous diffusion plants at Paducah, Kentucky and Portsmouth, Ohio, as defined by recent reliability studies. This work will encompass at Paducah, the restoration and replacement of selected structure, piping, fill and cable on a variety of cooling towers and replacement of the 480 volt fan switchgear in all four pumphouses and at Portsmouth, the replacement of 480 volt process auxiliary substation breakers in the X-326 and X-330 Process Buildings and additional facilities for impoundment of sludge generated in the water treatment plant. In addition, this project provides for upgrading the Paducah facility to permit withdrawal of higher assay material.

1/ Excludes $84,000 sequestered by the Balanced Budget and Emergency Deficit Control Act of 1985, Public Law 9-177.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Utilities upgrading, Phase III, Paducah, Kentucky and Portsmouth, Ohio

2. Project No. 84-N-405

9. Purpose, Justification of Need for, and Scope of Project:

The purpose of this project is to renovate, upgrade, or replace utility systems or components vital to the continued reliable operation of the diffusion cascade and support buildings. Equipment that has become worn out, obsolete, and unreliable is to be upgraded as necessary to improve the safety, reliability, and efficiency of plant operations for the long-term future.

Components of the cooling towers at Paducah have exceeded their expected life and have deteriorated with usage. The structures are still in serviceable condition, but the fill material in some of the towers (the section where the heat transfer occurs) is disintegrating. The upper decks are also deteriorating and becoming hazardous. The water distribution systems on top of the towers have extensive internal corrosion and scaling of the piping and deterioration of the wood that degrades the water distribution and cooling efficiency of the entire tower. These components must be replaced. The conduit and cable serving the cooling tower fans has deteriorated beyond repair and must be replaced in order to withstand the severe environmental conditions.

The electrical switchgear serving the critical auxiliary equipment in the process buildings at Portsmouth and the cooling tower fans on all of the cooling towers at Paducah have deteriorated with age and usage. The manufacturers of this equipment have either ceased manufacturing these components or have gone out of business entirely and replacement parts are very difficult to obtain. Parts must be custom made or substitutions found. It is now necessary to renovate this switchgear on a programmed basis in order to restore the necessary reliability for continued operation and personnel safety.

At Portsmouth the treatment of water for plant use produces a sludge that must be disposed of in an acceptable manner. The existing lagoon will continue to receive this sludge; however, current projections indicate that the present capacity will be filled by the early 1990's. Although the present lagoon complies with all current environmental regulations for disposal, expansion is required to meet future operational requirements.

With the Oak Ridge plant in a standby condition, only the Portsmouth plant is capable of producing enriched uranium with an assay above 2 percent. To meet customer requirements (delivery/shipment dates), it is necessary to upgrade the Paducah plant to be capable of withdrawing material with an assay above 2 percent. Modifications will be made to certain cascade equipment and decontamination systems to provide critically safe geometrics to meet the higher assay requirements. A plant wide criticality alarm system is required and will be provided with this added scope of work.

The FY 1987 obligational authority of $6,800,000 will provide for completion of the project.

A delay in the implementation of the project will result in continued deterioration of these critical systems and increase the risk, perhaps significantly, of serious operational interruptions to the cascades.

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Utilities upgrading, Phase III, Paducah, Kentucky and Portsmouth, Ohio

2. Project No. 84-N-405

10. Details of Cost Estimate:

	Paducah	Portsmouth	Total
a. Engineering, design and inspection at approximately 14% of construction costs, Item b.	$ 2,200	$ 700	$ 2,900
b. Construction costs	13,300	6,300	19,600
(1) Other structures	9,500	0	9,500
(2) Special facilities	3,500	6,300	9,800
(3) Standard equipment	300	0	300
Subtotal	15,500	7,000	22,500
c. Contingency at approximately 20% of above costs	3,816	600	4,416
Total estimated costs	$19,316	$ 7,600	$26,916

11. Method of Performance:

Design and inspection will be performed under a negotiated architect-engineer contract except that some switch-gear replacements will be done by the operating contractors. To the extent feasible, construction and procurement will be accomplished by fixed-price contract(s) and subcontracts(s) awarded on the basis of competitive bidding. Long delivery and special procurements will be accomplished by the operating contractors as will tie-ins and work on operating equipment.

12. Funding Schedule of Project Funding and Other Related Funding Requirements:

	Prior Years	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	Total
a. Total project costs										
1. Total facility costs										
(a) Construction line item	$ 0	$ 676	$3,832	$1,740	$1,200	$2,700	$7,000	$5,600	$4,168	$26,916
(b) PE&D	0	0	0	0	0	0	0	0	0	0
(c) Expense funded equipment	0	0	0	0	0	0	0	0	0	0
(d) Inventories	0	0	0	0	0	0	0	0	0	0
Total facility costs	0	676	3,832	1,740	1,200	2,700	7,000	5,600	4,168	26,916
2. Other project costs										
(a) R&D necessary to complete construction	0	0	0	0	0	0	0	0	0	0
(b) Conceptual design costs	351	0	198	0	0	0	0	0	0	549
(c) Other project related costs	0	0	0	0	0	0	0	0	0	0
Total other project costs	351	0	198	0	0	0	0	0	0	549
Total project costs	$ 351	$ 676	$4,030	$1,740	$1,200	$2,700	$7,000	$5,600	$4,168	$27,465

CONSTRUCTION PROJECT DATA SHEETS

1. Title and location of project: Utilities upgrading, Phase III, Paducah, Kentucky and Portsmouth, Ohio

2. Project No. 84-N-405

12. Funding Schedule of Project Funding and Other Related Funding Requirements: (Continued)

b. Other related annual costs (estimated life of project facilities: 15 years)

1. Facility operating costs	$ 0
2. Programmatic operating expense directly related to the facility	0
3. Capital equipment not related to construction but related to the programmatic effort in the facility	0
4. Maintenance, repair, GPP or other construction related to programmatic effort in the facility	0
5. Other costs	0
Total other related annual costs	$ 0

13. Narrative Explanation of Total Project Funding and Other Related Funding Requirements:

a. Total project costs
   1. Total facility costs. No narrative required.
   2. Other project costs
      (a) No narrative required.
      (b) The majority of conceptual design was completed prior to FY 1984 at a cost of $351,000. Additional conceptual design was undertaken in FY 1985 associated with the additional criticality work at Paducah, at a cost of $198,000.
      (c) No narrative required.

b. Other related annual costs
   1. Facility operating costs are expected to be reduced due to decreased maintenance. No additional operating personnel will be required.
   2 thru 5. No narrative required.

Geothermal Resources
Development Fund

DEPARTMENT OF ENERGY

Proposed Appropriation Language

Geothermal Resources Development Plan

For carrying out the Loan Guarantee and Interest Assistance Program as authorized by the Geothermal Energy Research, Development and Demonstration Act of 1974, as amended, $72,000, to remain available until expended: Provided, That the indebtedness guaranteed or committed to be guaranteed through funds provided by this or any other appropriation Act shall not exceed the aggregate of $500,000,000. (Public Law 99-141, making appropriations for energy and water development, 1986.)

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
LEAD TABLE
GEOTHERMAL RESOURCES DEVELOPMENT FUND
(Tabular dollars in thousands. Narrative material in whole dollars)

Geothermal Resources	FY 1985 Appropriation	FY 1986 Adjusted Appropriation	FY 1987 Base	FY 1987 Request	Request vs Base
Development Fund (CE)					
Program Direction Operating Expenses	$ 121	$ 69	$ 69	$ 72	+$ 3
Total	$ 121	$ 69	$ 69	$ 72	+$ 3
Staffing	1	1	1	1	0

Authorization: P.L. 93-410, Geothermal Energy Research Development and Demonstration Act of 1974, Title II
P.L. 95-238, Department of Energy Act of 1978 - Civilian Applications, Title V
P.L. 96-294, Energy Security Act, Title VI

Department of Energy

FY 1987 Congressional Budget Request

Adjustments to FY 1986 Appropriations

	FY 1986 Conference	Gramm-Rudman-Hollings Reduction	Adj. Approp. Total
Geothermal Resources Development Fund (CE)			
Program Direction			
Operating Expenses	$ 72	$ -3	$ 69
Total, Geothermal Resources Development Fund	$ 72	$ -3	$ 69

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
GEOTHERMAL RESOURCES DEVELOPMENT FUND
SUMMARY OF CHANGES

(Dollars in Thousands)

FY 1986 Appropriation adjusted	$ 69
Program increases and decreases:	+$ 3
FY 1987 Budget Request	$ 72

DEPARTMENT OF ENERGY
FY 1987 CONGRESSIONAL BUDGET REQUEST
GEOTHERMAL RESOURCES DEVELOPMENT FUND NARRATIVE

The goal of the Geothermal Loan Guaranty Program is to encourage the commercial production of energy from geothermal resources by guarantying lenders against loss of principal and interest on loans made to qualified borrowers for geothermal projects. Further, the program strives to develop normal borrower-lender relationships which will provide financing of geothermal projects without direct Federal sharing of the risk.

	FY 1986 Adjusted Approp.	FY 1987 Request	Net Change
Geothermal Resources Development Fund....	$ 69,000	$ 72,000	+$ 3,000

The FY 1987 Budget Request includes funds for program direction. These funds will support one person who will provide overall program guidance and direction for the multi-million dollar Geothermal Loan Guaranty Program. This person will also evaluate and monitor current loan guaranties which have either been issued or are pending issuance.

The FY 1987 Budget Request for the Geothermal Resources Development Fund is $72,000. The represents an increase of $3,000 from the adjusted FY 1986 appropriation.